QH 1 N49 c.1

Library
NOAA, National Marine Fisheries Serv
SWFC Honolulu Laboratory F/SWC2
2570 Dole Street
Honolulu, HI 96822-2396

Southwest
FISHERIES SCIENCE CENTER

HONOLULU | LA JOLLA | MONTEREY | TIBURON

REPORT OF ACTIVITIES — First Quarter 1994

ANTARCTIC ECOSYSTEM RESEARCH GROUP — Page

1994 AMLR Cruise Completed 1

COASTAL FISHERIES RESOURCES DIVISION

United States and Mexico to Study Return of Historic Multimillion-dollar Sardine Fishery 4

MARINE MAMMAL DIVISION

Program's FAD Projects Reviewed, 1991-1994 5

HONOLULU LABORATORY

SeaWiFS Will Provide Remote Sensing of Ocean Color 8

PACIFIC FISHERIES ENVIRONMENTAL GROUP

Sidescan Sonar Used to Evaluate Rockfish Habitat: Examples from Monterey Bay 16

PELAGIC FISHERIES RESOURCES DIVISION

Sixth Annual Consultation of Parties to the South Pacific Regional Tuna Treaty Held in Nadi, Fiji 21

TIBURON LABORATORY

Analysis of the First and Second Annulus from Lingcod Fin Rays Completed 24

INFORMATION TECHNOLOGY SERVICES

Software and Services on the La Jolla LAN Summarized 27

PUBLICATIONS 28

SOUTHWEST FISHERIES SCIENCE CENTER

CENTER ADMINISTRATION- La Jolla, California

Science and Research Director, SWR ..... *Michael F. Tillman*
Deputy Director ..... *Richard A. Neal*
Planning Officer ..... *David J. Mackett*
Information Technology Services ..... *Dorothy Roll*
Executive Officer ..... *Sherrie L. Rasmussen*

LABORATORIES & DIVISIONS

Antarctic Ecosystem Research Group, Chief ..... *Rennie Holt*
La Jolla, California
Coastal Fisheries Resources Division, Chief ..... *John R. Hunter*
La Jolla, California
Marine Mammal Division, Chief ..... *Robert L. Brownell, Jr.*
La Jolla, California
Honolulu Laboratory, Director ..... *R. Michael Laurs*
Honolulu, Hawaii
Pacific Fisheries Environmental Group, Chief ..... *George W. Boehlert*
Monterey, California
Pelagic Fisheries Resources Division, Chief ..... *Gary T. Sakagawa*
La Jolla, California
Tiburon Laboratory, Director ..... *Alec MacCall*
Tiburon, California

This report does not constitute a publication and is for information only. Its contents should not be cited or reproduced.

Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Editor: Connie Blair
Layout: Roy Allen

The Report of Activities of the Southwest Fisheries Science Center is compiled at La Jolla from material submitted by the Center's staff. To change the delivery address of the Report of Activities, or to cancel your subscription, please notify Esther Perez, at P.O. Box 271, La Jolla, CA 92038-0271. Telephone: (619) 546-7058.

ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

1994 AMLR Cruise Completed

On March 15, 1994, the NOAA Ship *Surveyor* returned to the port of Punta Arenas, Chile, completing the U.S. Antarctic Marine Living Resources (AMLR) program's annual research cruise in the waters surrounding Elephant Island, South Shetland Islands, Antarctica. The AMLR program, which is managed by the Antarctic Ecosystem Research Group (AERG) at the Southwest Fisheries Science Center (SWFSC) in La Jolla, California, has been conducting research in this 15,000-square-mile area of the Southern Ocean for six consecutive austral summers. The AMLR program provides information needed to formulate U.S. policy on the conservation and international management of resources living in the oceans surrounding Antarctica. The program advises the U.S. delegation to the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), part of the Antarctic treaty system.

The long-term goal of the AMLR field program is to describe the functional relationships between krill (the keystone element of the Antarctic marine ecosystem), its predators (mainly penguins and seals), and key environmental variables. As in past seasons, the 1994 field program included shipboard studies of the pelagic ecosystem in the vicinity of Elephant Island as well as land-based studies of reproduction and feeding behaviors of krill predators breeding on Seal Island, a small island off the northwest coast of Elephant Island.

The Seal Island field camp was reactivated on November 30, 1993, when the field team arrived via the tourist ship *Explorer*. Foraging studies on Antarctic fur seals, *Arctocephalus gazella*, began immediately with the deployment of radio transmitters on 40 lactating female seals during their perinatal visits to a breeding colony. The average duration of foraging trips made by each animal was estimated, a parameter which is sensitive to prey availability within the foraging area.

To monitor the foraging effort of diving birds, time-depth recorders (TDRs) were deployed on chinstrap penguins, *Pygoscelis antarctica*, at 10 nests during the incubation phase of their breeding cycle. Light intensity data, collected continuously while the TDRs were recording diving behavior, will be used to ascertain whether variations in ambient light influence the bird's foraging efficiency.

An automatic direction-finding (ADF) system was installed at the highest point of Seal Island. The system recorded the direction of signals received from VHF radio-transmitter tags deployed on fur seals and chinstrap penguins and allowed for monitoring the directions the animals traveled to and from their foraging areas.

Daily counts of live and dead fur seal pups encountered at island colonies were made throughout the season. As in the past, all sightings of leopard seals ashore and at sea were opportunistically recorded to assist with interpretation of trends in fur seal abundance and recruitment. In past years, a considerable number of fur seal pups have been taken by leopard seals. Also, the team monitored previously tagged female seals for reproductive success.

By the end of December, hatching of chinstrap penguin chicks was about 66 percent completed at one main colony and 40 percent at another. The team noted that the beach near the field camp had become noticeably more crowded with younger, non-breeding chinstrap penguins; they also observed an increase in the number of breeding adults enroute to and from foraging trips following the hatching of their chicks.

In the first few days of January, monitoring of fur seal pup growth rates began. One hundred pups were weighed individually, and the procedure was repeated at biweekly intervals throughout the season. After the first weighing, mean weights for both male and female pups were found to be typical as compared to past seasons. Chinstrap penguins continued to hatch, with about 90 percent completed at this time. The completion of hatching marked the commencement of several penguin research procedures, including a census of CCAMLR penguin colonies to estimate breeding success, attachment of radio transmitters for monitoring foraging trip duration, and sampling of the chicks' diets.

The field team began observations of 25 Cape Petrel, *Daption capense*, nests to establish their breeding chronology, thereby allowing determination of the optimal timing for later measurements of breeding success and chick condition at a larger group of nests. CCAMLR has selected the Cape Petrel as a species to be monitored because of its potential high sensitivity to krill availability.

Meanwhile, beginning its cruise, the *Surveyor* departed from Punta Arenas via the eastern end of the Straits of Magellan on January 12, 1994. The ship arrived at Seal Island on January 15, and fresh food provisions and other supplies were offloaded to the field team on the island. In addition, two personnel were transported to the island and two other personnel already on the island were brought to the ship, where they conducted shipboard research during Leg I of the cruise. The weather was cooperative and resupply was completed without incident.

On January 16, the ship traveled to King George Island, where the acoustic system was calibrated. That day, the scientific party initiated a large-area survey, consisting of 91 conductivity-temperature-depth (CTD)/rosette and net sampling stations, separated by approximately 1,365 nautical miles (nmi) of acoustic transects. The objectives of the large-area survey were to describe the thermohaline structure of the water and to assess phytoplankton biomass and productivity, major zooplankton constituents, and krill biomass.

During the acoustic transects, krill and other zooplankton were located using an acoustic survey system, comprised of a Simrad EK500 echosounder, two down-looking transceiver/transducer subsystems mounted in the ship's hull (120-kHz and 200-kHz), one side-looking transducer (120-kHz) situated in a dead-weight towed body, and two Sun SparcStations for data logging and postprocessing. Operations at each station included (1) measurements of temperature, salinity, oxygen, light transmission, and fluorescence; (2) collection of discrete water samples at standard depths for analysis of chlorophyll-*a* content, absorption spectra, particulate organic carbon and nitrogen content, primary production, ATP and DNA content, size fractionation, floristics, and inorganic nutrient content; and (3) deployment of a 6-ft (1.8 m) Isaacs-Kidd-Midwater-Trawl (IKMT), fitted with a 505-micron nytex net, to obtain samples of zooplankton and nekton (krill). On January 29, rough seas and high winds resulted in the termination of the large-area survey; seven stations on the eastern edge of the survey grid were not completed.

On Seal Island in late January, TDRs were recovered from female fur seals that had completed at least six post-partum foraging trips. The TDR data provide detailed records of foraging effort and diving performance of individual seals. Also at this time, chinstrap penguins were observed to be entering the creche phase of their breeding cycle. The creche phase is characterized by chicks being left unattended while both parents from a nest forage simultaneously to meet the increasing food demand of the growing chicks. Another species of penguin, the macaroni, *Eudyptes chrysolphus*, also made the transition to the creche stage, and a census of nests and chicks was conducted as a measure of reproductive success for this species.

In early February, the field team began tagging fur seal pups. Annual tagging of fur seal pups and resighting of the tagged animals in subsequent years allows for estimation of survival and recruitment rates. Also, the annual banding of 2,000 chinstrap penguin chicks was begun. By this time, the chicks were molting from their downy chick feathers into their juvenile plumage: brilliant slate blue backs with white chests and the distinctive thin black "chinstrap" markings on their chins. The first molting of adult penguins was also noted; molting in adult penguins occurs when old worn feathers are replaced, which provides a new insulative layer. During this 3-to-4 week process, the birds refrain from going into the water.

Back on ship, a small-area acoustic survey was conducted to the north of Elephant Island from January 30 through February 2; the survey followed a 30 x 30 nmi grid and was conducted at a ship's speed of 5 knots. The survey was designed to elucidate krill patch structure of an area of historically high krill densities, which is also the primary foraging grounds of seals and penguins breeding on Seal Island. Beginning February 3 and based on the results of the small-area survey, nighttime-directed sampling using a multiple opening/closing net and environmental sensing system (MOCNESS) was conducted to capture krill swarms detected by the acoustic transducers. Ten MOCNESS tows were completed.

During daylight hours of February 2 through 4, fur seal pups at two breeding sites on Elephant Island were counted. In addition, a survey for previously unknown or newly colonized sites was conducted along coastlines of several islands in the Antarctic Peninsula. During selected transects of the small-area survey and during the nights of February 2 and 3, a floating sled with two attached radio transmitters was towed behind the ship. The signals from the transmitters were monitored by personnel on Seal Island to calibrate the island's ADF system.

On the morning of February 4, *Surveyor* again arrived at Seal Island to exchange personnel. Two National Marine Mammal Laboratory biologists

who had been conducting research aboard *Surveyor* during Leg I were transported to Seal Island and three personnel from the island were picked up to be returned to Punta Arenas and then home.

Surveyor then returned to the large-area survey grid and completed sampling at the seven remaining stations which had not been done earlier due to poor weather. The ship crossed the Drake Passage and returned to Punta Arenas on February 9. During the port call, the ship took on supplies and received Leg II scientific personnel.

The ship departed from Punta Arenas on February 14 for Leg II of the cruise, again via the eastern end of the Straits of Magellan. During the transit, personnel from the Servicio Hidrografico y Oceangrafica de la Armada (SHOA) conducted 18 expendable bathythermographs (XBTs) across the Drake Passage to locate the position of the polar front and to document the extent of the Antarctic winter surface water, which is evidenced by a minimum temperature at depths between 80 and 100 meters.

Immediately following a resupply visit to Seal Island, a small-area acoustic survey was conducted north of Elephant Island; the survey was similar to the one conducted on Leg I and sought to describe the abundance, distribution, and density of krill in the area. The survey was completed on February 19. MOCNESS tows were conducted in two areas of high krill density that were identified during this survey.

On Seal Island, the field scientists continued to investigate chinstrap penguin chick diet samples. In addition to krill, other prey items found in the samples included fish, squid, and occasionally amphipods and copepods. Toward the end of February, the number of subadult male fur seals on the beach and in breeding colonies on the island increased considerably. Penguin fledging continued to progress. Fledging is a stage when the young penguins become independent of the parents. A sample of fledglings were captured and measured prior to their first trip to sea to provide an indication of their health and chance of survivorship.

On February 20, a drogue experiment was initiated aboard the ship to describe the vertical and horizontal movement of krill swarms relative to the upper mixed layer of the ocean. A small buoy equipped with a radar reflector and drogue (underwater parachute) was deployed for 24 hours in a 1.5-square-mile area where acoustic surveys revealed significant krill patches. Side-looking and down-looking acoustic observations were made from the ship while transiting a survey pattern relative to the position of the buoy. The buoy drifted out of the area of high krill density, suggesting that the krill were actively maintaining their position.

Following the drogue experiment, a transect was conducted across Bransfield Strait, extending northwest of Nelson Island. The transect consisted of acoustic observations and fixed stations with CTD/rosette and net sampling operations. The ship then transited to Elephant Island to conduct similar acoustic and sampling operations in a transect across the shelf-break north of the island. Next, a large-area survey, a replicate of the one conducted during Leg I, was conducted from February 25 to March 7. Throughout the cruise, continuous measurements of incident visible radiation, spectral ultraviolet radiation, and meteorological parameters were recorded from shipboard sensors. Water temperature, salinity, light beam attenuation, and chlorophyll-*a* fluorescence were recorded from the ship's clean intake water line at 5 meters depth. In addition, observations of birds and marine mammals were recorded by observers on the flying bridge.

At the field camp, monitoring of Cape Petrel chicks continued with chicks being weighed, measured, and banded. This event is timed to take place as chick weight peaks, just prior to the chick's fledging. Since these airborne predators can forage over greater areas than the penguins and thereby have the opportunity to exploit a different ecological niche, Cape Petrels are an important species to monitor. The final fur seal pup weighing was conducted in late February, as was the tagging of 198 pups. Initial analyses indicated that pup growth rates were similar to past seasons. The field team also spent this time making the many preparations necessary for the closing of the camp.

Following the completion of the large-area survey, the ship transited to Admiralty Bay at King George Island to calibrate the acoustic transducers. A second drogue experiment was then conducted, and a line of CTD stations was occupied east of the large-area survey grid.

The Seal Island field team spent the last days of the season completing their observations of chinstrap penguin fledglings and the final stages of closing the field camp. On March 10, the ship called at the island to retrieve the entire field team. The ship then transited the Drake Passage to Punta Arenas, bringing to a close a successful 1994 AMLR field season. (J. Rosenberg, [619] 546-5600)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

United States and Mexico to Study Return of Historic Multimillion-dollar Sardine Fishery

The Mexican Secretariat of Fisheries (SEPESCA), and the California Department of Fish and Game (CDF&G) and Coastal Fisheries Resources Division at the Southwest Fisheries Science Center (SWFSC) will survey U.S. and Mexican west coast waters from April 11 to May 11, 1994, to investigate the resurgence of the Pacific sardine. Researchers will sample sardine eggs and adult fish found in the sardine's 20,000-square-mile historic range from San Francisco southward to Punta Abreojos, Baja California, Mexico, and seaward 200-300 miles. The data will be used to estimate the sardine biomass using the daily egg production method (DEPM), which was developed at the SWFSC.

This DEPM survey is the biggest and most comprehensive ever conducted. Pablo Arenas of the Inter-American Tropical Tuna Commission is acting as the project coordinator.

The Pacific sardine fishery, immortalized by John Steinbeck in the book *Cannery Row*, once supported the largest fishery in the western hemisphere before its collapse in the late 1960s. In its heyday from the mid-1930s to mid-1940s, the catch averaged 600,000 tons per year. Signs of recovery of the sardine population began in the 1980s, but the extent of the recovery is unknown due to its transboundary range and because, working separately, the United States and Mexico lacked the resources to accomplish such a comprehensive project.

Fishermen from both countries will benefit if the sardine population continues to recover. If the fishery should fully recover, the sardine population may be able to sustain an annual U.S. harvest of 227,000 tons, with a current-day value to fishermen of about $20 million.

This survey goes far beyond measuring the abundance of the sardine, however. Out of this joint effort, U.S. and Mexican scientific partnerships are being formed to study various physical and biological aspects of the California Current, which will be measured during the course of the study. Joint projects will include the following studies:

- age-specific reproductive effort of the sardine;
- dynamics of the California Current south from San Francisco through Baja California;
- age structure of the recovering sardine stock, with cross validation of ageing techniques between CDF&G and NMFS in the United States, and Instituto Nacional de la Pesca in Mexico;
- determination of latitudinal trends in sardine vital rates (growth, reproductive rates, age, maturity, and egg and larval mortality);
- temperature-specific spawning geography of the sardine;
- genetic structure of the sardine population;
- spring inventory of the neustonic (near-surface swimming) larvae of the California Current; and
- temperature-specific spawning geography of the sardine.

Two NOAA research vessels, *McArthur* and *David Starr Jordan*; two research vessels from Mexico, *Puma* and *BIP XII*; and one vessel from CDF&G, *Mako*, will participate in the study. Scientists from NMFS' La Jolla laboratory and those of CDF&G will be responsible for determining the Pacific sardine population along the U.S. west coast. Scientists from SEPESCA's Instituto Nacional de la Pesca will study the population found on the Mexican west coast.

In addition to scientists from the Instituto Nacional de la Pesca, Mexican researchers participating in the project are from the Universidad Nacional Autónoma de México, Centro de Investigación de Ciencias del Mar, Centro de Investigación Científica y de Educación Superior de Ensenada, and from other institutions in Baja California, Sonora, and Mexico City. (J. Hunter, [619] 546-7127)

Pacific Mackerel Biomass Estimated

Management of Pacific mackerel, *Scomber japonicus*, by the California Department of Fish and Game (CDF&G) has traditionally been based on biomass estimates from virtual population analysis (VPA). However, VPA biomass estimates for recent years are no more than educated guesses unless information about recent trends in abundance is available.

Until recently, information about trends in abundance was not available for Pacific mackerel.

During 1993-1994, the Coastal Division has worked cooperatively with CDF&G to improve biomass estimates used to manage Pacific mackerel. Two types of indices for relative abundance of Pacific mackerel have been developed and included in an assessment model. The first type of relative abundance index (SPOTTER) is based on fish spotter data. The second type is based on California Cooperative Oceanic Fisheries Investigation (CalCOFI) data, provided by Fishery Biologist Geoff Moser and Computer Specialist Richard Charter of Southwest Fisheries Science Center (SWFSC). The assessment model is a VPA variant known as ADAPT, which was chosen because VPA was familiar to biologists working at CDF&G.

Fish spotters are pilots employed by commercial fishers to locate, identify, and estimate the size of fish schools. During the course of normal operations, fish spotters collect data on all fish schools observed. The fish spotter data are then used by Statistician Nancy C. H. Lo (SWFSC) to obtain an index of relative abundance for Pacific mackerel and other species.

Two indices based on CalCOFI data are available. The first index of relative abundance for Pacific mackerel (DENSITY) is calculated as the density of larvae collected during individual tows. The second index of relative abundance (%POSITIVE) is calculated as the percent of individual tows in which Pacific mackerel larvae were found. Use of %POSITIVE as an index of relative abundance for Pacific sardine was pioneered by Fishery Biologist Paul Smith (SWFSC) and Marc Mangel (University of California, Davis). %POSITIVE may be preferable to DENSITY in some situations because it has lower variance. For purposes of standardization, only CalCOFI data obtained from the current CalCOFI grid are used.

Abundance indices for Pacific mackerel are difficult to interpret because the area occupied by the stock (along the Pacific Coast from Alaska to Mexico) is much smaller than the area surveyed (approximately the Southern California Bight). Abundance may tend to increase outside the area surveyed so that the indices may "saturate" and not increase at the same rate as biomass.

A recent paper by Terry Dickerson (CDF&G) and Fishery Biologist Beverly Macewicz (SWFSC) provided estimates of age-specific net fecundity (eggs per gram) required to interpret the CalCOFI data. Net fecundity of Pacific mackerel is almost zero at age 1 and increases in a nearly linear fashion as the fish age. SPOTTER data appear to be a measure of recruitment strength (biomass at age 1) for Pacific mackerel. Thus, CalCOFI and fish spotter data, when used together, appear to measure relative abundance of the "all" age classes.

Results of the assessment model developed by SWFSC and CDF&G (Fig. 1) reflect the spectacular increase in Pacific mackerel biomass which took place in the late 1970s and early 1980s and was followed by almost continuous declines beginning in 1982. Although imprecise, estimates of current biomass for Pacific mackerel are on the order of 50,000 to 100,000 short tons. (L. Jacobson, [619] 546-7117)

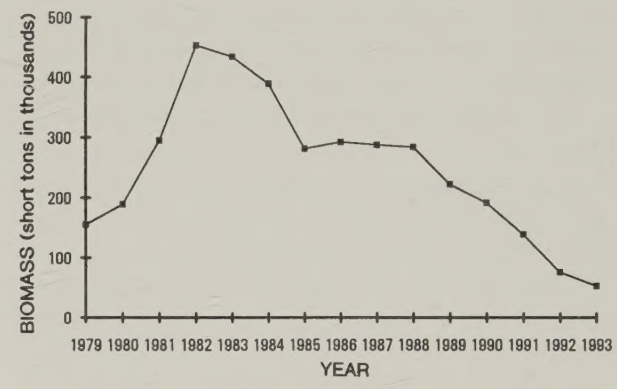

Figure 1. Midyear biomass estimates for Pacific mackerel age 1 and older, from U.S. and Mexican waters, 1979-1993.

MARINE MAMMAL DIVISION

La Jolla, California

DOLPHIN-SAFE PROGRAM

Program's FAD Projects Reviewed, 1991-1994

The Inter-American Tropical Tuna Commission (IATTC) and the National Marine Fisheries Service (NMFS) since 1991 have been cooperating on joint research projects to explore mechanisms of attracting mature tuna to FADs (fish aggregating devices) in sufficient quantities that fishing activity on tuna in association with dolphins can be decreased. Although the precise mechanisms involved in the

attraction of fish to floating objects are unknown, this behavior occurs with sufficient regularity to justify research efforts that explore the use of FADs to enhance dolphin-safe fishing efforts in the eastern tropical Pacific Ocean (ETP). This report briefly summarizes the research to date.

Past Activities: 1990-1992

Sea kites were provided in 1990 to captains of several purse seine vessels who volunteered to construct and deploy subsurface arrays for their drifting FADs. Sea kites are pyramidal structures, measuring 6 feet (1.8 meters) on a side, and are constructed with a fiberglass pole frame and yellow "rip-stop" nylon. A number of kites were attached at regular intervals to a weighted monofilament mainline suspended in the water from the surface buoy. Seven FADs with NMFS' sea kite arrays were deployed, and they remained in the water from 2 hours to 19 days. Observations of accumulations of forage fish, barnacles, and crabs were reported, but no tuna were observed and no sets were made on these FADs.

In January of 1991, two identical, satellite-trackable FADs were deployed by two purse seine vessels. These FADs were deployed to test the durability of the surface buoys and electronic components, and the practicality of tracking FADs by satellite to provide more-or-less continuous position information to fishing vessels. Positions and estimations of drift transmitted to vessels searching for the FADs were fairly accurate and sightings of the FADs by NMFS observers indicated that the surface buoys were in good condition.

Positions of low profile, wave- and wind-resistant drifting oceanographic buoys (drifting FADs) were provided by Don Hansen of Atlantic Oceanic and Meteorologic Laboratory, Miami, Florida, to Southwest Fisheries Science Center (SWFSC) at La Jolla, California, via OMNET twice each week from March 21, 1991, through October 5, 1992. These data were transmitted to interested purse seine skippers and owners on a weekly basis. Three sets were made on drifting buoys and significant quantities of tuna were caught. The ability of anchored oceanographic buoys to attract fish has been noted by personal observations of NMFS observers and purse seine fishermen, but these buoys are not actively promoted as FADs by the Dolphin-Safe program as fishing near or around these structures could damage them.

In late July 1991 NMFS, Bumblebee Seafoods Inc., and the IATTC deployed 30 FADs constructed of 10 different designs and equipped with various tracking and locating devices. The design of the surface buoys ranged from surface units only to surface units with arrays descending to 100 meters in depth. FADs were deployed in 10 groups, each group consisting of three identical FADs. One FAD in each group was equipped with a satellite transmitter that transmitted positions through the ARGOS satellite system. The other two were equipped with selective-calling (SELCALL), medium-wave radio buoys which operate only when activated by a vessel's signal generator. The satellite transmitters provided positions that were accurate to within a kilometer or less and position data could be accessed daily through the Service ARGOS satellite system. SELCALL radio buoys can be interrogated by vessels at distances up to 200 kilometers (km).

These FADs were deployed 1,609 km (1,000 miles) offshore Mexico in an area from 9° to 11° N between 121° and 124° W. This area and the region to the west where the FADs were expected to drift are the traditional fishing grounds for large yellowfin tuna caught in association with dolphins. IATTC's historical data also indicated that adjacent areas, although not especially rich in natural logs, had produced larger-than-average yellowfin than is usual for log sets.

All FADs were launched within a 24-hour period in roughly a 2° x 3° area. The deployment around the 10° N latitude appears to have overlapped the north equatorial countercurrent and the north equatorial current, as several of the FADs drifted in a northwesterly direction while others, positioned a short distance away, drifted to the southeast. Those drifting to the northwest eventually turned to the west. Those drifting to the southeast circled around to the northeast and then to the west as they encountered a westerly current near 12° N latitude. FADs were tracked for several months by NMFS and IATTC staff at the SWFSC in La Jolla, California, and daily positions were provided to vessel managers and IATTC field offices throughout Latin America.

The first failure of a satellite transmitter was recorded on November 6, 1991, 106 days after deployment, and was followed by the failure of a second satellite transmitter on November 8, 1991. The last positions obtained for the eight remaining satellite-equipped FADs were received from Service ARGOS Inc. on April 20, 1993, and indicated a continued westward movement well outside the fishing grounds. IATTC ceased providing weekly positions to their field offices on September 28, 1992,

because all the remaining groups of FADs were well west of the fishing grounds. A Spar-type, SELCALL radio-equipped FAD was recovered by a fisherman from the Province of Southern Leyte in the Republic of the Philippines in May 1993. Technicians from the Fisheries Research Division of the Bureau of Fisheries and Aquatic Resources, Manila, Philippines, retrieved the device and contacted the IATTC.

Current Activities: 1993-1994

Dolphin-Safe Questionnaire. Dolphin-Safe Research Program personnel created a questionnaire for tuna fishermen to solicit advice, stimulate suggestions, and offer critiques of existing and proposed methods to catch mature yellowfin tuna without encircling dolphins. The questionnaires will provide information about the types of support NMFS/IATTC could provide fishermen in terms of equipment, gear research projects, and data. Questionnaires were distributed at the IATTC Organizational Meeting of the Scientific Advisory Board in San Diego during April 1993, and several have been mailed to owners and skippers in the U.S. fleet. Currently, two U.S. purse seine captains are participating in studies on anchored or drifting FADs.

Anchored FADs. In December 1992, a U.S. tuna fleet skipper (Skipper-A) contacted the Dolphin-Safe Program and expressed interest in procuring materials to construct and deploy anchored FADs in waters 280-1,000 meters deep offshore Costa Rica. The vessel owners provided materials to construct surface buoys and anchors, and NMFS supplied mooring line in November 1993. Skipper-A will construct at least five anchored FADs to be deployed in 1994. He will assemble anchored FADs using one or both of the following designs: (1) He will build multichambered metal surface buoys with a truck tire affixed to the bottom of each buoy. Several loops of steel cable will be threaded through the middle of the tire, and this cable will then be spliced and clamped to 100 meters of steel cable attached to a large swivel. Mooring line joined to the swivel will lead to the bottom and be connected to a large swivel coupled to the anchor's bridle. Anchors will be constructed of two 55-gallon drums filled with concrete. (2) The alternative design will incorporate all features of the previous model, plus a detachable buoy equipped with a generator and lights. Several hours before sunrise this buoy will be disconnected from the anchored surface buoy and towed away by a speedboat so that a set can be made away from the mooring. A logbook has been furnished to Skipper-A and NMFS will receive data on the design, construction, deployment, visits, sets, and catch on the anchored FADs.

Drifting FADs. The Dolphin-Safe program purchased five Ryokuseisha SV-CL3B SELCALL radio buoys during June 1993 and loaned them to a second U.S. fleet skipper (Skipper-B) in exchange for information about construction, deployment, visits, and sets on drifting FADs assembled during his "dolphin-safe" fishing trips. Skipper-B constructs drifting FADs out of surplus materials found aboard the ship, including old net webbing, used corkline, balloon floats, scrap lumber, and wooden crates and pallets. He incorporates "seasoned" flotsam found at sea into the structure, which includes logs, driftwood, dead whales, and abandoned or discarded fishing gear such as longline floats, tangled gillnets, plywood, and floating line.

A general FAD design used frequently by Skipper-B utilizes two 4-meter-long two-by-fours tied together with net twine. Used corks are tied to the tops of the boards. Net webbing, approximately 4 meters wide and 12 meters deep, is connected to the bottom of the two-by-fours. This design creates a curtain that can be rolled up for storage aboard the vessel, which simplifies deployment. A plastic, 55-gallon drum filled with discarded fish is connected to one end of the two-by-fours and a radio buoy is attached to this bait bucket with 20 meters of line. FADs are deployed as a group in areas where signs of tuna are detected. The radio buoys' signals can be activated from the seiner's helicopter, located, and the FADs checked for tuna.

Skipper-B is documenting the FADs he has used and is explaining how, where, and when they were constructed, deployed, and fished in a logbook provided to him by the Dolphin-Safe program. He has deployed 20 FADs during two separate fishing trips. On the first trip, five sets were made on FADs yielding a total of 27.5 tons of market-sized tuna (predominately bigeye tuna and a few tons of yellowfin and skipjack tuna). Fishing on FADs during this trip was not as successful as was hoped. During the second trip, an excess of 600 tons of market-sized bigeye, skipjack, and yellowfin was produced from eight sets. The first seven sets averaged 20-30 tons per set. At the time of the last set, 156 tons were needed to fill the ship's fish wells. This set proved to be exceptional. The skipper estimated that there were about 400 tons of tuna associated with this particular FAD and, in fact, he captured so much fish that it was necessary to cut the rings in order to release the excess 150-200 tons of live fish prior to brailing (hauling fish aboard using a dip net). These

data illustrate the variability of FAD productivity over a relatively short period of time (3-4 months). He has volunteered to furnish detailed information on all the FADs deployed during his trips and not just the FADs attached to NMFS radio buoys. One of the key disappointments realized during previous NMFS/IATTC FAD research projects was the lack of visits to FADs by tuna purse seine vessels. Since Skipper-B is deploying FADs with NMFS radio buoys in conjunction with his own gear, NMFS scientists are hopeful he will visit the NMFS FADs on a regular basis.

The Dolphin-Safe program has proposed deployment of two anchored FADs in an area where large yellowfin tuna are known to occur to determine if deep-water, anchored FADs are capable of attracting large yellowfin, bigeye, and skipjack tuna in economically attractive quantities. The cost to construct and deploy such anchored FADs on the high seas would range from $1,000 to several thousand dollars per unit. The wide range in cost estimates is influencing the design and quality of materials used to construct various components of the anchored FADs, which await funding for construction and deployment. (E. Edwards, [619] 546-7099)

HONOLULU LABORATORY

Honolulu, Hawaii

HAWAII REGIONAL COASTWATCH NODE

SeaWiFS Will Provide Remote Sensing of Ocean Color

The Coastal Ocean Program's Hawaii Regional CoastWatch Node (HRCN), Honolulu Laboratory, is dedicated to providing government agencies and researchers with remotely sensed environmental data to assist in managing living marine resources and coastal ecosystems. Toward this end, the HRCN, in cooperation with the National Weather Service (NWS), has expanded the capabilities of the NWS's satellite receiving station to acquire Seaviewing Wide Field-of-view Sensor (SeaWiFS) satellite data.

SeaWiFS data will bring to the ocean community a new and improved ocean color remote-sensing capability lost when the Nimbus-7 Coastal Zone Color Scanner (CZCS) failed in 1986. Scientists will use SeaWiFS data to help visualize the variability in ocean color that is related to the distribution of chlorophyll and other water constituents; in this system, changes in ocean color will reflect changes in primary productivity.

CZCS data collected in the past have provided researchers with a valuable tool for studying primary productivity changes on global scales. For example, global CZCS estimates of phytoplankton pigment concentrations averaged over the first week of June 1984[1] are shown in Figure 1.

Figure 1. Coastal Zone Color Scanner estimates of phytoplankton pigment concentrations during the first week of June 1984. Note the white areas of high productivity associated with coastal upwelling, such as off the west coast of both North and South America. (The high phytoplankton amounts indicated in the polar regions are artifacts of ocean icing and do not represent real values.)

Similar data will become available after the launch of the SeaStar satellite by Orbital Sciences Corporation (OSC); this satellite will be used to carry the SeaWiFS sensor. In order for researchers to gain quick access to these data, they must sign a "Dear Colleague Letter" with NASA. This letter is written so that users of SeaWiFS data agree to use the data only for noncommercial purposes. Other users must purchase SeaWiFS data from OSC. Investigators desiring SeaWiFS data should request a copy of the Dear Colleague Letter from Goddard Space Flight Center, SeaWiFS Project, Code 970.2, NASA, Greenbelt, Maryland 20771; telephone: (301) 286-9676; FAX: (301) 286-3221; Omnet: SeaWiFS Project. (C. Motell, [808] 943-1279)

[1]Additional CZCS data are available on CD-Rom. Contact Jet Propulsion Laboratory, Physical Oceanography Distributed Active Archive Center, User Support Office - Mail Stop 300-320, 4800 Oak Grove Dr., Pasadena, California 92119. Or Internet at ral@shrimp.jpl.nasa.gov.

PROTECTED SPECIES INVESTIGATION

1994 Field Studies Begin for the Hawaiian Monk Seal

On February 3 Protected Species Investigation (PSI) personnel departed on the NOAA Ship *Townsend Cromwell* (TC-94-01 Leg I) to begin 1994 field studies of the endangered Hawaiian monk seal, *Monachus schauinslandi*. Under the leadership of Fishery Biologist John Henderson, a field party was deployed at French Frigate Shoals to retrieve satellite transmitters from three subadult Hawaiian monk seals and to assess the status of immature seals. Since 1989 birth rates, growth and condition, and survival rates have changed markedly in this population; the most likely cause is decreased prey availability. The transmitters were applied as part of an effort to determine the foraging habitat of seals at this site. All three satellite transmitters have been recovered.

On the cruise a three-member PSI team led by Cooperating Scientist Mitchell P. Craig, Joint Institute for Marine and Atmospheric Research, University of Hawaii, and six juvenile monk seal females were also transported to Kure Atoll. The female monk seals had been collected from French Frigate Shoals during the summer and autumn of 1993 as part of an ongoing project to rehabilitate underweight immature females from this site. Fully rehabilitated, they were being taken to Kure for return to the wild population. The PSI team will remain on Kure until mid-March and will monitor the transition of these females and collect additional data on the status of the resident population at this site. The monk seal population at Kure is one of two populations that have experienced consistent positive growth during the last decade. Much of that growth is attributed to the release of rehabilitated females from French Frigate Shoals and to the Head Start project, where newly weaned females born at Kure were kept in an enclosure to facilitate their transition to independent feeding and to protect them from sharks and aggressive adult males. (M. Finn, [808] 943-1271)

INSULAR RESOURCES INVESTIGATION

Early Development of Pelagic Armorhead Described

The pelagic armorhead, *Pseudopentaceros wheeleri*, has been the focus of the Honolulu Laboratory's seamount research program since 1976 and was the dominant species in the foreign trawl fishery at the Hancock Seamounts north of Midway Island prior to the establishment of the 200-nautical-mile Exclusive Economic Zone. Despite numerous studies of pelagic armorhead recruitment, reproduction, larval distribution, age and growth, and larval feeding, there is no description of the early developmental stages of *P. wheeleri*. Fishery Biologists Bruce Mundy of the Honolulu Laboratory and Geoff Moser of the La Jolla Laboratory are completing a manuscript describing the morphology of a larva (Fig. 2) and small (<20 millimeters [mm] standard length) pelagic juveniles of this species.

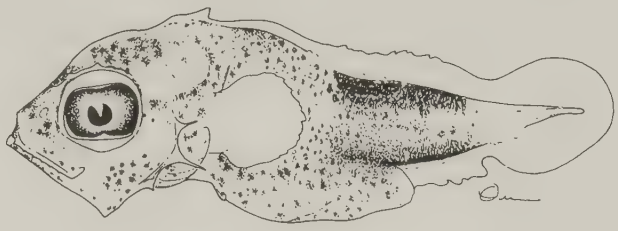

Figure 2. A 4.2-mm notochord-length larva of the pelagic armorhead, Pseudopentaceros wheeleri, collected at the Hancock Seamounts (approximately 30° N, 179° E) in February 1985 (illustration by Henry Orr, La Jolla Laboratory).

The manuscript also describes the larva of another armorhead (family Pentacerotidae) from Australia: the sailfin armorhead, *Histiopterus typus*. The early development of the two species is compared with previous descriptions of larvae of three other pentacerotids, and a set of larval characters is identified that is unique to this family. Characters that distinguish pelagic armorhead larvae from other pentacerotids and similar larvae in other families are given.

All pelagic armorhead larvae and juveniles <20 mm standard length collected at the Hancock Seamounts were taken in samples limited to the upper 2 meters of the water column, despite numerous tows taken at other depths. The neustonic occurrence of early life history stages of pelagic armorhead probably aids in their dispersal away from the seamounts by wind-driven currents. Previous studies by the Honolulu Laboratory of other aspects of life history have suggested that pelagic armorhead are not retained at, and probably do not return to, their natal seamounts. Evidence from the distribution of larvae and small juveniles supports this conclusion. (B. Mundy, [808] 943-1227)

PELAGIC RESOURCES INVESTIGATION

Fish and Cephalopod Catch in North Pacific High-seas Driftnet Fisheries Estimated for 1990 and 1991

From the late 1970s through their termination on December 31, 1992, large-scale high-seas driftnet fisheries were the dominant fisheries in the North Pacific Transition Zone (NPTZ). Neon flying squid, *Ommastrepres bartramii*, and two faunal groups, tunas and billfishes, were targeted by the driftnet fisheries. The squid driftnet fishery was comprised of vessels from Japan, Taiwan, and the Republic of Korea that targeted neon flying squid. The large-mesh driftnet fishery was comprised of other vessels from Japan and Taiwan that targeted tunas and billfishes.

The rapid expansion of large-scale driftnet fishing during the early 1980s led to increasing concern over the incidental killing of nontargeted species (including marine mammals, sea birds, turtles, and salmonids) by the NPTZ driftnet fisheries and its potential impact on the ecosystem, resulting in the adoption of stricter time-area regulations and development of international monitoring programs. In 1989 a cooperative pilot scientific observer program in the Japanese squid driftnet fishery was established between Japan, Canada, and the United States. Later bilateral observer programs were launched by the United States and the Republic of Korea and by the United States and Taiwan, and the U.S.-Japanese-Canadian agreement was expanded to include the Japanese large-mesh fishery. The goals of the scientific observer programs were to monitor driftnet fishing operations and obtain data on the rates of incidental take of various species of fish, marine mammals, turtles, and birds in an effort to estimate total mortalities and assess impacts on the affected populations. Before the observer data could be fully analyzed and evaluated, however, increased public concern over the potential impact of these fisheries resulted in a global United Nations ban on large-scale driftnet fishing in the North Pacific Ocean effective December 31, 1992.

Total catches (numbers and biomass) of squids and pelagic fishes in the North Pacific high-seas drift gillnet fisheries have been estimated for the 1990 and 1991 fishing seasons. These estimates are based on data collected by multinational scientific observers on Japanese, Korean, and Taiwanese squid and large-mesh driftnet vessels and on reported commercial fishing effort for all fleets operating in the NPTZ during the 1990 and 1991 fishing seasons. Catch was examined relative to the type of fishery (squid or large-mesh), the flag of the vessels involved (Japanese, Korean, or Taiwanese), and physical and operational factors affecting catchability.

An initial step toward estimating total catches required the assessment of "dropouts" during net retrieval. A dropout was defined as an animal that emerged from the water entangled in the net but which became disentangled and fell out of the net before it reached the deck, either on its own accord or due to deliberate shaking of the net by the crew. A General Linear Model was used to study the effects of species, observer nationality, time of day, sea state, and mesh size on fleet-specific retrieval dropout rate. Because not all explanatory variables were available in the fleet data, simplified fleet-specific models involving only species and observer nationality effects were used to estimate appropriate mean dropout rates for "scaling up" catch rates. Total catches by species and month were estimated using a ratio estimator. Species-specific metrics of exploited biomass were estimated by apportioning total catches into length categories based on length-frequency data collected by observers, then converting catch by length to catch by weight using existing or derived length-weight relationships. Precision of the estimates of total catch was evaluated by bootstrap resampling.

Summaries of total fleet fishing effort, observed fishing effort, and observer coverage rates in the 1990 and 1991 fishing seasons are presented in Tables 1 and 2. Observers reported 8 cephalopod and 76 fish species caught in the 1990 and 1991 fishing seasons, representing five faunal groups—squids, sharks, tunas (mackerels and tunas), billfishes, and other pelagic fishes. Percent catch composition by fleet and faunal group is depicted in Figure 3 (See page 12).

For most species, dropout rates were similar between years. However, differences in dropout rates between fisheries were apparent. Dropout rates were generally lower in the large-mesh fisheries than in the squid fishery for all fish species. The range of dropout rates by faunal group and fleet is presented in Table 3.

Although the magnitude and composition of catches differed between fisheries and years, highest combined total catches were generally associated with intended target(s): neon flying squid by the squid driftnet fleets and albacore tuna, *Thunnus*

Table 1. 1990 scientific observer coverage of the North Pacific high-seas driftnet fisheries.

Fishery	No. trips observed	No. operations observed[a]	Observer effort[b]	Total commercial effort[c]	Percent coverage
Japanese squid	74	2,879	2,281,896	22,636,075	10.1
Korean squid	24	911	669,662	24,556,676	2.7
Taiwanese squid	12	356	171,170	2,348,284	7.3
Taiwanese large-mesh	9	358	194,953	7,104,787	2.7
Japanese large-mesh[d]	24	829	512,213	4,682,630	10.9

[a]An operation = each setting and retrieval of the driftnet.
[b]Observer effort is expressed as standardized net panels.
[c]Commercial effort is expressed as standardized net panels in the Japanese and Korean fisheries and as vessel days in the Taiwanese fisheries.
[d]Japanese large-mesh fishery covers the 1990-91 fishing season.

Table 2. 1991 scientific observer coverage of the North Pacific high-seas driftnet fisheries.

Fishery	No. trips observed	No. operations observed	Observer effort[a]	Total commercial effort[a]	Percent coverage
Japanese squid	60	2,659	2,063,965	21,709,643	9.5
Korean squid	23	642	422,517	20,419,877	2.1
Taiwanese squid	9	342	160,720	4,440,024	3.6
Taiwanese large-mesh	11	436	237,512	2,759,454	8.6

[a]Observer and commercial effort is expressed as standardized net panels in the Japanese, Korean and Taiwanese fisheries

Table 3. Range of dropout rates (percent) by faunal group and fleet.

	Fishery				
Faunal group	Japanese squid	Korean squid	Taiwanese squid	Japanese large-mesh	Taiwanese large-mesh
Sharks	26	18-26	30-42	7-15	0-12
Tunas	10-25	3-13[a]	10[a]	4-8	2-7
		18-23[b]	22-28[b]		
Billfishes	15-20	33-44	17-24	1-6	0-5
Other pelagic fishes	15-30	10-20	10-30	<5	10-35

[a]Small tunas (mackerel, *Scomber* spp., and bullet tuna, *A. rochei*)
[b]Large tunas (albacore tuna, *Thunnus alalunga*, and skipjack tuna, *Katsuwonus pelamis*)

alalunga; skipjack tuna, *Katsuwonus pelamis*; and striped marlin, *Tetrapturus audax*, by the large-mesh driftnet fleets. While the catches by the Japanese squid fleet were dominated by neon flying squid, nontargeted pelagic species of low economic value (LEV) accounted for approximately 40 percent of the total numbers of cephalopods and fishes caught on an annual basis. LEV species are defined as those species included in the two faunal groups "other pelagic fishes" and "sharks." Paramount among LEV species caught by the Japanese squid fleet were Pacific pomfret, *Brama japonica*; pelagic armorhead, *Pseudopentaceros wheeleri*; blue shark, *Prionace glauca*; and yellowtail, *Seriola lalandi*, with

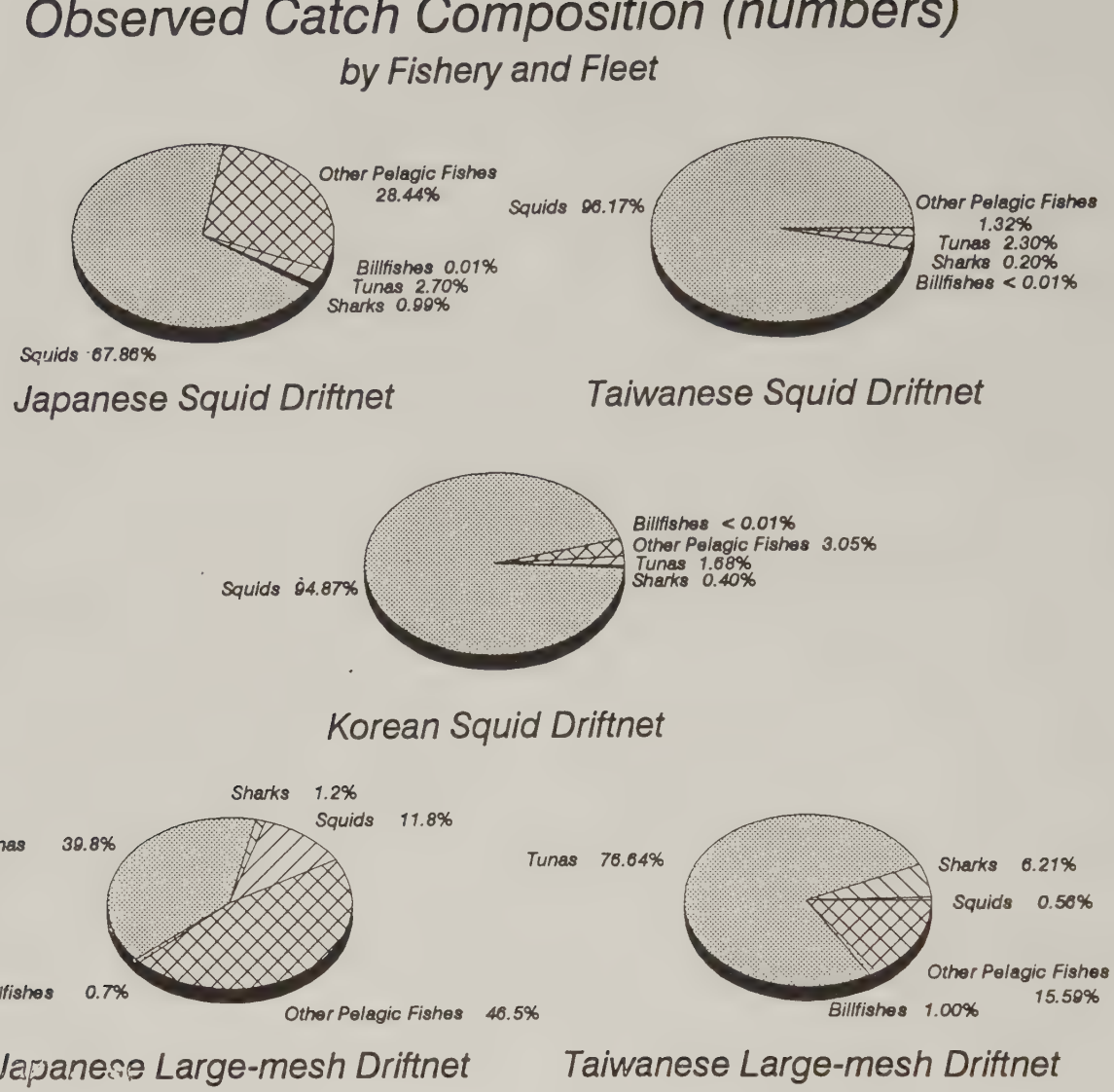

Figure 3. Percent observed catch composition by fleet and faunal group in the 1990-91 North Pacific high-seas driftnet fisheries.

catch estimates of approximately 35.1, 3.2, 0.9, and 0.1 million animals in 1990 and 17.5, 0.9, 0.9, and 0.2 million animals in 1991, respectively. Relatively large numbers of LEV species including Pacific pomfret, blue shark, and yellowtail were also caught by the Korean and Taiwanese squid driftnet fleets. In 1990 approximately 9.0, 0.7, and 0.07 million and 0.6, 0.1, and 0.005 million Pacific pomfret, blue shark, and yellowtail were caught by the Korean and Taiwanese squid fleets, respectively. In 1991, approximately 1.4, 0.6, and 0.4 million and 0.3, 0.1, and 0.008 million Pacific pomfret, blue shark, and yellowtail were caught by the Korean and Taiwanese squid fleets, respectively.

The catches by the Taiwanese large-mesh fleet were predominately albacore tuna (5.2 million in 1990, 0.7 million in 1991) and skipjack tuna (0.4 million in 1990, 0.3 million in 1991), but species of LEV were also taken, in particular, Pacific pomfret (1.3 million in 1990, 0.08 million in 1991). The catches by the Japanese large-mesh fleet were predominately species of LEV, Pacific pomfret (1.5 million) and mahimahi (0.3 million) being most prevalent. Relatively large numbers of albacore tuna (0.2 million) and skipjack tuna (1.4 million) were also caught as well as neon flying squid (0.6 million).

Highest estimates of total biomass removed occurred in the squid driftnet fisheries. During 1990 and 1991 combined, approximately 461,000 metric tons (t) of squid and fish were caught by the squid driftnet fleets compared with 59,000 t by the large-mesh fleets. Highest biomass removed in the squid fishery was associated with the Japanese fleet (approximately 231,000 t) followed by the Korean (approximately 142,000 t) and Taiwanese (approximately 88,000 t) fleets. In the large-mesh fishery, approximately 45,000 t of fish were caught by the Taiwanese fleet during the 1990-91 fishing seasons. Approximately 14,000 t of fish were caught by the Japanese large-mesh fleet during the 1990-91 fishing season.

Within fleets, highest biomass removal estimates were associated with target species, followed by species of LEV. Paramount among LEV species were Pacific pomfret and blue shark. Interannual variability was observed in biomass removal estimates, particularly for target species and species of LEV.

The average weight and length of key species were generally larger in the large-mesh fisheries than in the squid fisheries. Within the squid driftnet fishery, no apparent trend in average weight and length of key species was observed between fleets. However, in the large-mesh fishery, the Japanese fleet generally caught larger fish compared with the Taiwanese fleet. (G. DiNardo, [808] 943-1259)

Studies Completed on the Horizontal and Vertical Movements of Striped Marlin and the Effects of Entanglement on North Pacific Albacore

A study on the horizontal and vertical movements of striped marlin, *Tetrapturus audax*, near the Hawaiian Islands has recently been published in *Marine Biology*. The paper was coauthored by Fishery Biologists Richard W. Brill and Randolph K. C. Chang, Honolulu Laboratory; David B. Holts, SWFSC, La Jolla; Scott Sullivan, NOAA Corps; Heidi Dewar, Scripps Institution of Oceanography; and Francis G. Carey, Woods Hole Oceanographic Institute.

Ultrasonic telemetry was used in the study, with simultaneous measurement of oceanic currents. Fish movements were monitored using ultrasonic depth-sensitive transmitters, depth-temperature profiles were made using an expendable bathythermograph system, and oceanic current patterns were measured using an acoustic Doppler current profiler. Striped marlin near Hawaii, like Indo-Pacific blue marlin, *Makaira mazara*, spent over 85 percent of their time in the mixed layer (that is, above 90 m). The maximum depth in which striped marlin are found appears to be limited by water temperatures 8 °C colder than the mixed layer rather than by an absolute lower temperature. In addition, the study showed that the horizontal displacements of some striped marlin can be strongly influenced by currents.

Brill and Holts also coauthored another recent publication, "Effects of entanglement and escape from high-seas driftnets on rates of natural mortality of North Pacific albacore, *Thunnus alalunga*," which was published in *Fishery Bulletin* (1993, volume 91).

In this publication, they explain that foreign driftnet fleets and U.S. trollers taking albacore target a common stock and that albacore that encounter the driftnets, then escape and survive long enough to be recaptured by another fishery, can bear some external marks. U.S. trollers operating in the North Pacific have reported an increased frequency of net-marked fish with the expansion of the Taiwanese, Korean, and Japanese high-seas driftnet fleets. This study was undertaken to determine whether albacore that encounter driftnets, and subsequently escape alive, suffer higher than normal rates of natural mortality.

Differences in rates of natural mortality were measured by standard fitness, short- and long-term growth rates, and indications of bacterial infection and long-term stress. The indirect measures were employed because rates of natural mortality (or physiological changes) could not be directly observed in albacore encountering simulated driftnets in shoreside tanks.

No differences were found in any parameter that would indicate differences in natural mortality. Most fish recaptured by trollers were only minimally damaged or had healed scars, which may explain the lack of differences. There is most likely a spectrum of damage caused during encounters with driftnets. The number of albacore dying from falling out, or escaping so badly injured that they are unable to resume feeding before becoming vulnerable to recapture by troll vessels, may well be significant but remains to be determined. (R. Brill, [808] 943-1234)

FISHERY MANAGEMENT AND PERFORMANCE INVESTIGATION

Pelagic Fishing Vessel Economics Project Under Way

Three new researchers for the NMFS Honolulu Laboratory project on Hawaii pelagic fishing vessel economics have begun their orientation to the Hawaii pelagic fishery and the related economic and fishery management issues. The project is part of the Pelagic Fisheries Research Program, and the researchers are Michael Travis, principal research assistant, and Rita Curtis and Marcia Hamilton, research associates.

Travis recently completed a doctorate in economics from the University of Notre Dame. His dissertation, "Lemon laws and dispute resolution mechanisms: An economic analysis of power," analyzes the differential impact of manufacturer-sponsored and government-run dispute resolution mechanisms. The empirical work uses both qualitative and quantitative techniques, including binary and multinomial logistic regressions.

Curtis received her master's degree in agricultural and resource economics from the University of Maryland. In her thesis on land use valuation, she uses hedonic analysis (which relates the price of land with its quality attributes) to determine the value of benefits provided by open space as well as the externality effects associated with alternative land uses.

Hamilton received her master's degree in agricultural and resource economics from the University of Hawaii; her thesis was on the economics of cut flower production and focused on production efficiency with an emphasis on the contribution of labor to output. Hamilton also recently completed a contract with the NMFS Pacific Area Office on the economics of bottomfishing vessels in the Northwestern Hawaiian Islands (SWFSC Administrative Report H-94-1C).

The overall objectives of the proposed research are to determine the economic characteristics and optimal number (and spatial distribution) of Hawaii-based domestic longline fishing vessels, identify the determinants of longline fishing vessel operations (spatial, temporal, and species) relative to interaction with other domestic fishing fleets, and identify the economic characteristics of commercial troll-handline and charter boat operations. (For this study, charter boat [sport fishing] operations are considered to be commercial since they are businesses, even though they may provide entertainment to their customers. Recreational is used to mean fishing operations which are not commercial.)

The objectives specific to first-year funding include the following:

(1) Cost-earnings: to determine the basic cost-earnings and fishing operations relationships of longline, pelagic handline, and commercial troll fishing and charter boat vessels in Hawaii.

(2) Exogenous fishing effort: to develop a model of the impact of fish price and factor input prices on the supply of fishing effort in these fisheries.

(3) Endogenous fishing effort: to develop a model of dynamic factors of at-sea longline fishing effort behavior, which relates to factors internal to the decision-making framework of the fisherman. This aspect of the research will lead to models of dynamic factors of at-sea fishing behavior and probable independent variables will include the catch rate experienced, the weather, and cost of operations.

The research should provide fishery management information based on the economic characteristics of the Hawaii longline, troll-handline, and charter boat fisheries. The primary client for the research is the Western Pacific Regional Fishery Management Council, a Federal organization authorized under the Magnuson Fishery Conservation and Management Act of 1976 that regulates fishing within the U.S. 200-mile Exclusive Economic Zone surrounding Hawaii, as well as American Samoa, Guam, and the Commonwealth of the Northern Marianas.

The project is part of the Pelagic Fisheries Research Program, which is funded through the University of Hawaii's School of Ocean and Earth Science and Technology (SOEST) and its Joint Institute for Marine and Atmospheric Research. The program is the outgrowth of a collaborative process including the Council, SOEST, and NMFS. The Hawaii Pelagic Fishing Vessel Economics project is expected to last 3 years, depending on funding availability for the second and third years. Sam Pooley, industry economist, is the principal investigator at the Honolulu Laboratory. (S. Pooley, [808] 943-1216)

Northwestern Hawaiian Islands Bottomfish Fishery: Vessel Activities, Costs, and Economic Returns Analyzed

Research Assistant Marcia Hamilton recently completed a study on the Northwestern Hawaiian Islands (NWHI) bottomfish fishery which has been published as Honolulu Laboratory Administrative Report H-94-01C. The study was prepared under contract to the NMFS Pacific Area Office, in cooperation with the Western Pacific Regional Fishery Management Council (WPRFMC) and the Honolulu Laboratory.

Hamilton's study focused on the 12 vessels which had reported bottomfish landings from the NWHI during the period January-November 1993. Of these 12 vessels, 4 were active in the Ho'omalu (limited entry) Zone and 8 in the Mau (open access) Zone. Vessel owners or captains were interviewed and requested to project their operations to the end of 1993.

Based on this information, all Ho'omalu Zone boats were found to be engaged exclusively in commercial bottomfishing with a 1993 average of 9 trips per vessel, calculated to be 73.3 percent of their potential full-time operations. For the Mau Zone vessels, the average vessel made 22 trips in 1993, with 12.75 of these targeting commercial bottomfishes, 3.38 targeting large pelagics or mixed target species, and 0.25 involved in commercial nonfishing trips (2 charter trips by one vessel). The remaining 5.63 trips were to the main Hawaiian Islands targeting commercial bottomfishes (0.88 trips), for recreational fishing purposes (4.5 trips), or as commercial nonfishing trips (0.25 trips consisting of 2 charter trips by 1 vessel). Vessels in this zone were calculated as operating at 76 percent of their full-time potential. (Because several boats were used part of the time for purely recreational fishing and others had experienced major breakdowns, the captains were asked the maximum number of commercial trips they would take in a year if it were not for the recreational use and/or excessive breakdowns experienced that year. The intent was to determine the maximum effect this fleet could have on the fishery if every boat fished commercially at its maximum capability.)

An analysis of the effects on catch by the vessels' physical characteristics (such as size and fuel capacity) was attempted. However, no single physical vessel characteristic was found to statistically explain more than 42 percent of the variation in 1993 projected maximum catch rates at a statistically significant level. Thus, the data in this report were separated by fishing zone only.

Economic analysis of the costs and returns reported by the NWHI fleet revealed that on average Ho'omalu Zone vessels would realize a 1993 return of $2,238 per vessel, while Mau Zone vessels would average a 1993 loss of $21,947 per vessel. If the Ho'omalu Zone fleet were to operate at a full-time level, each vessel could achieve an average return of $20,533. However, full-time operations in the Mau Zone would still yield an average loss of $19,497. If the entire NWHI bottomfish fishery is considered as a whole (vessels in both zones are averaged together), the average vessel would realize a 1993 loss of $15,351. Actual operation levels for the entire NWHI were found to be 75.5 percent of potential full-time fishing days (as defined by survey participants); if the fleet were to operate at a full-time level, the average vessel would realize a loss of $8,574.

Based on this information, along with the relevant maximum sustainable yields as stated in the Bottomfish Fishery Management Plan (1986), the entire NWHI can economically sustain 14.6 vessels on a part-time basis or 12.8 on a full-time basis. The Ho'omalu Zone is found to be capable of economically sustaining 7.3 vessels on a part-time basis or 6.1 vessels on a full-time basis. The Mau Zone can economically sustain 5.1 vessels on a part-time basis or 4.4 on a full-time basis.

This information can be used by the WPRFMC to determine whether to allow new entrants into the Ho'omalu Zone or to change the conditions for entry into the Mau Zone.

In the study, Hamilton also examined the motivations of bottomfish vessel owners, captains, and owner operators. Their responses are summarized in Table 4 (See page 16). The most important motivation among owner operators in the Mau Zone is the primary income provided by their vessels. They are also motivated equally by the long-term investment goals and recreational enjoyment provided by their vessels. Hired captains cited enjoyment of the lifestyle offered by fishing as their most important motivation, and they are also motivated by plans to take over vessel operations.

Since the owner of the only Ho'omalu Zone vessel with a hired captain did not respond to this question, the responses of all Ho'omalu Zone ves-

Table 4. Motivations of active Northwestern Hawaiian Islands vessel captains and owners, 1993. Hyphens represent no response.

	MAU ZONE						HO'OMALU ZONE	
	Owner-operated vessels $N = 5$		Hired captain vessels $N = 3$				All vessels $N = 4$	
	Owner/captain		Captain		Owner			
	Most important	Somewhat important	Most important	Somewhat important	Most important	Somewhat important	Most important	Somewhat important
Enjoy the lifestyle	20%	60%	67%	33%	N/A	N/A	--	50%
Enjoy the work itself	--	20%	--	67%	N/A	N/A	25%	25%
Primary source of income	60%	40%	33%	--	--	--	50%	25%
Source of additional income	--	20%	--	--	--	33%	--	--
No other source of employment	--	20%	--	--	--	--	--	--
Long term family tradition	--	--	--	33%	--	--	--	50%
Long term investment goals	20%	20%	N/A	N/A	33%	33%	--	50%
Tax write off	--	--	N/A	N/A	--	33%	--	--
Cover a portion of fixed costs	20%	--	N/A	N/A	--	--	--	--
Recreational purposes	--	--	N/A	N/A	33%	--	--	--
Plan to operate it myself	N/A	N/A	N/A	N/A	33%	--	--	--

sels are presented together. For this group, the dominant motivation is primary source of income. (M. Hamilton, [808] 943-1264)

PACIFIC FISHERIES ENVIRONMENTAL GROUP

Monterey, California

Sidescan Sonar Used to Evaluate Rockfish Habitat: Examples from Monterey Bay

As a participant in a special workshop, "Applications of Sidescan Sonar and Laser Line Systems in Fisheries Research," at the 8th Western Groundfish Conference (Nanaimo, British Columbia, January 17-20, 1994), Fishery Biologist Mary Yoklavich presented aspects of her project on the importance of small-scale refugia to deepwater rockfishes in submarine canyons. The project is an interdisciplinary, multi-year study supported by NOAA National Underseas Research Program and conducted by fisheries biologists from NOAA, National Marine Fisheries Service's Pacific Fisheries Environmental Group (PFEG); Moss Landing Marine Laboratories; the California Department of Fish and Game; the Marine Science Institute at the University of California, Santa Barbara; and geologists from the U.S. Geological Survey.

Even with decreased landings in recent years, rockfish are among the most valuable fisheries in California. As local nearshore stocks become depleted, deepwater species are becoming more important. Along the central California coast, several submarine canyons cut into the continental shelf and bring deep water close to shore. As their name suggests, many species of rockfishes are associated with rock substrata. Yoklavich and the other researchers hypothesize that isolated rock outcrops along steep canyon walls act as natural refugia for exploited rockfish species, allowing them to attain larger sizes and higher abundance than in adjacent, more heavily fished areas.

By combining remote-census geophysical techniques, in situ submersible observations, and infor-

mation from the recreational fishery (Fig. 1), the researchers are evaluating rockfish resources, including species composition, abundance, and size distribution, within heavily-fished and lightly-fished areas of similar depth and microhabitat in the Monterey Bay submarine canyon system and nearby areas. First, however, they produced an accurate high-resolution bathymetric basemap of Soquel Canyon from which they identified areas of potential slumped rocks and located submersible dive sites where rockfish were likely to be found (Fig. 2).

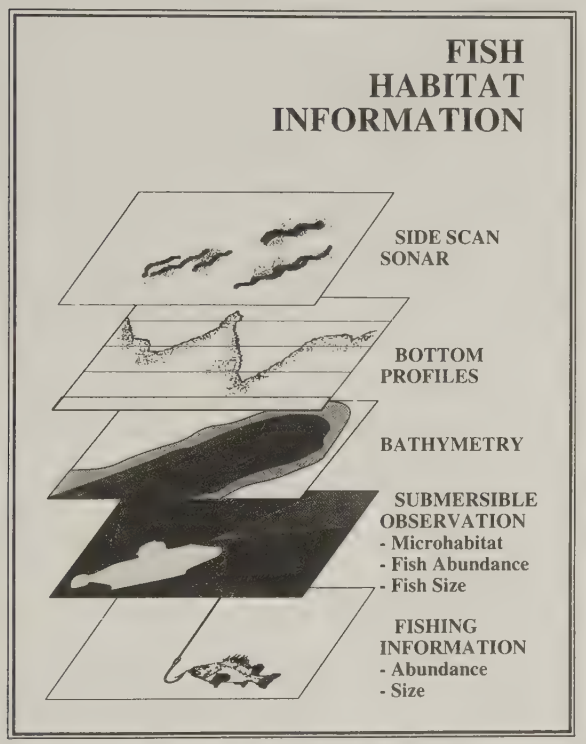

Figure 1. Datasets included in rockfish habitat evaluation, collected from Monterey Bay, California, and nearby areas.

Yoklavich and the researchers conducted side scan sonar surveys of Soquel Canyon and parts of Monterey Canyon and of Año Nuevo and Ascension Canyons, which are located north of Santa Cruz in the Monterey Bay Submarine Canyon. They also surveyed shallow rock outcrops historically fished within the bay. Side scan sonar is the perfect method for differentiating blocks of hard substrata, which appear dark from surrounding soft sediments because of different reflectivity (Fig. 3). The sonographs along each track line were combined with navigational plots to form mosaics of benthic habitat types. The mosaics are used to quantify exposed hard substrata available at depths suitable to rockfishes. Sonograph interpretation is

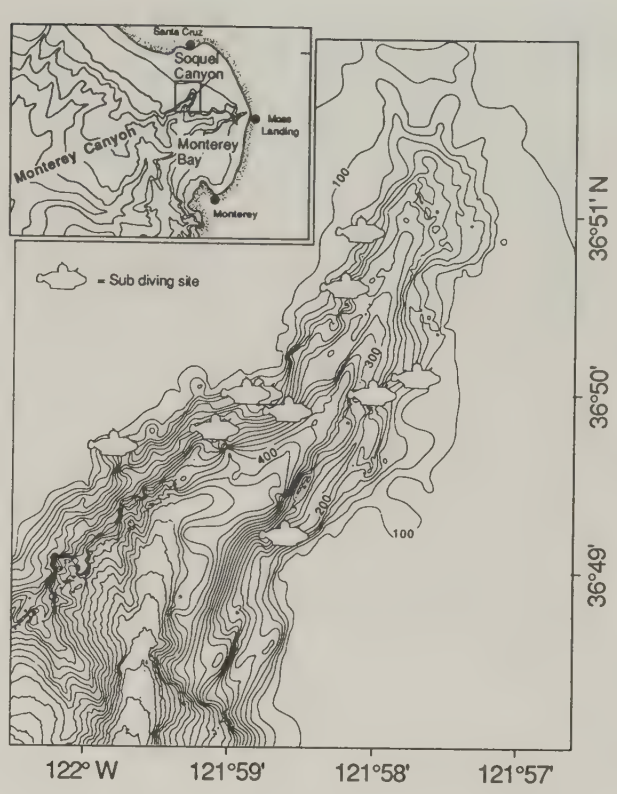

Figure 2. Fine-scale bathymetric map of Soquel Canyon in the Monterey Bay Submarine Canyon, California, produced from a 3.5-kHz bottom profiler. Sites of submersible dives are included. Depth contours are in 20-m intervals.

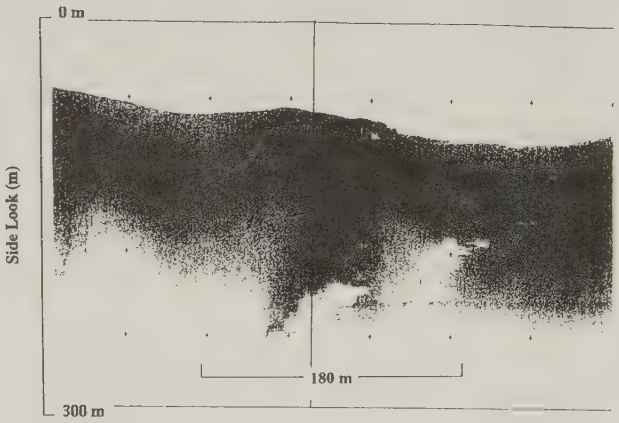

Figure 3. Side scan sonograph of outcrop on wall of Soquel Canyon. Strong acoustic reflectors (black areas) are from exposed bedding faces (the blacker the image, the harder the substrate), white areas are shadows behind faces, and gray areas are the result of mud, which returns a weaker acoustic signal. These mudstone beds comprise the rockfish habitat.

verified with submersible observations and integrated with microhabitat information.

Soquel Canyon is characterized by extensive erosion with sharp, steep relief and many isolated rock outcrops that provide ideal shelter for large fishes. The most likely rockfish habitat in the landward parts (most nearshore areas) of Monterey, Ascension, and Año Nuevo Canyons appears in sonographs as well-defined ledges of sedimentary rock. Rockfish habitat at historically fished sites within the Bay comprises large areas of elevated granite and sedimentary outcrops surrounded by flat mud-sand seafloor. Secondary to fish habitat characterization, these results extend our knowledge of regional seafloor geology and provide associated high-resolution maps of the area.

From preliminary analyses of 80 video-documented submersible dives made during August 1992 and October 1993, at least 35 species of rockfishes have been identified. Species composition, size, abundance, and habitat specificity are being evaluated. Rockfish habitat types include vertical cliffs with joints, fractures, and overhangs; small and large ledges; talus slopes; and boulders of exposed mudstone interspersed with soft mud. Several distinct assemblages of rockfishes were obvious from initial observations. Large schools of young-of-the-year rockfishes were documented over shallow (90-120 m) rock areas of low relief outside the submarine canyons and were almost absent at any depth within the canyons. Very specific assemblages of small species, previously considered uncommon, occurred in high numbers over offshore submerged beach terraces of well-rounded cobble. High numbers of large species (up to 1 m) were closely associated with ledges, caves, and overhangs on steep sides of canyons. Observations from more heavily fished areas suggest that these large species are likely protected from excessive harvest by inhabiting inaccessible isolated outcrops in the canyons.

The researchers are continuing analyses of the video transects using a geographical information system to map and analyze these spatially referenced datasets. Fish assemblage and habitat associations in offshore submarine canyons will be surveyed from a submersible September 19-27, 1994. Integrating side scan sonar and submersible surveys is very effective in assessing fish assemblages with heterogeneous distributions that are closely associated with deepwater rocky areas and unavailable to other methods of evaluation. (M. Yoklavich, [408] 656-3293)

Cadmium and Upwelling in the California Current

Oceanographer David Husby and Alexander van Geen of the U.S. Geological Survey, Menlo Park, California, have completed a manuscript titled "Cadmium in the California Current system: Tracer of past and present upwelling." The manuscript describes research in which they made times series samplings of silicon, phosphorous, and cadmium (Cd) at coastal sites between 36° and 41° N during 1991 through 1993. They found that variations in nearshore Cd concentration over the 3 years closely followed a polynomial function of the coastal upwelling index at 36° N, which is calculated routinely. The correlation between the Cd measured in coastal waters and the Cd measured in waters associated with alongshore winds near the coast was weaker. The relation between Cd concentrations and a monthly upwelling index was used to show that coastal water Cd averaged annually varied over a two-fold range since 1946 due to fluctuations in atmospheric pressure distributions over the northeast Pacific. Data from the samplings indicated that the intensity of upwelling varied significantly from year to year. The decrease in upwelling over the past 4,000 years as recorded from samples of forminifera collected in San Francisco Bay underlines the sensitivity of atmosphere-ocean circulation in eastern boundary currents to climate change. (D. Husby, [408] 656-3311)

International Symposium Held on Middle-sized Pelagic Fishes

Fisheries Biologist Richard Parrish recently attended the International Symposium on Middle-sized Pelagic Fishes, which was sponsored by the Facultad de Ciencias del Mar of the Universidad de Las Palmas de Gran Canaria. Parrish chaired the last session of the meeting, Fish Population Dynamics (Evaluation and Management), and presented the introductory talk for this session. He and Jorge Csirke cochaired the discussion session, which followed the formal presentations.

The highlights of the meeting included an excellent series of papers on *Trachurus* fisheries and a good working differentiation between small pelagics and midsized pelagics. Carlos Bas, one of the organizers of the meeting, suggested that small pelagics tend to be more coastal in their distributions and less migratory in their habits than midsized pelagics, the distinction here being on the size of the fish rather than on the species. Under this concept, anchovies and small clupeids as well as

small/young mackerel, *Scomber* or *Trachurus*, can be described as small pelagics. On the other hand, larger/older mackerel, *Scomber* or *Trachurus*, as well as bonito, *Sarda*, can be described as midsized pelagics.

In his introductory talk, Parrish noted that the majority of fisheries research programs for small and midsized pelagics are currently focused on three quite distinct problems: (1) determination of current biomass for real-time management decisions, (2) process-oriented studies of inter-year variation in recruitment, and (3) research on regime and climate scale processes. Unfortunately, there is little agreement as to which problem is the most significant; in addition, a research program designed to address one of these problems provides very little information on the other two problems.

Determination of biomass for current management decisions is largely limited to fishery-independent surveys and fishery-dependent models, which are ranked below in terms of both highest cost and highest precision.

1. Egg production surveys	$$$$$
2. Acoustic surveys	$$$$
3. Cohort analysis models	$$$
4. Stock synthesis models	$$
5. Catch/effort models	$

Surveys are generally considered to be more accurate than models, but they are expensive and their use is largely limited to those fisheries that are larger and more valuable. Parrish pointed out that the precision of surveys is really limited to one significant number. For example, a hydroacoustic survey may be able to distinguish between a biomass of 600,000 tons (t) and a biomass of 700,000 t, but it cannot distinguish between 680,000 t and 690,000 t.

The principal difficulty with models is what has been termed the retrospective problem (that is, models are better at estimating past biomass than current biomass). In addition, for many stocks of midsized pelagics, the incoming year-class may be a significant proportion of the exploited biomass, and recruitment has proven to be very difficult to forecast. Although rather precise current biomass estimates (that is, those having two or three significant numbers) are often presented by fisheries modelers, there are few fishery models that really have even one significant number. For example, not many fishery models can distinguish between a current biomass of 80,000 t and 90,000 t.

Worldwide, there are few examples of successful management of midsized pelagic fishes and, with the exception of recent examples from the International Council for Exploration of the Sea region, the few that exist have been unilateral management regimes. Unilateral management systems (such as those which regulate the fisheries for small and midsized pelagics such as California anchovy, sardine, and mackerel) have not proven to be successful when a significant proportion of the stock is available to other nations. (R. Parrish, [408] 656-3336)

Long-term and Seasonal Patterns Examined in Near-shore Environmental Time Series Along the North, Central and South American West Coast

An examination of long-term time series of numerous physical and biological parameters from the California Current system shows that major ecosystem changes occur on decadal scales. One of the best examples of this is in an analysis of the well-referenced series of sea surface temperature (SST) from Scripps Pier in La Jolla, California. The patterns and trends seen in the Scripps Pier SST series are reflected to a varying extent at other coastal-site SSTs along the west coast of North America as well as in the large-scale Pacific and even global SST records (for example, the blended SST anomalies for the northern hemisphere [Folland and others 1990]). Superimposed on an observed long-term warming trend from 1916 through 1992 are numerous interannual perturbations, principally El Niño/Southern Oscillation (ENSO) events, as well as decadal-scale fluctuations, such as periods of slightly increasing and even decreasing temperature followed by rapid increases in temperature.

Discussions of climate change usually do not define what constitutes climate change. It may simply be a change in the mean, but in examining these patterns of change, researchers at the Pacific Fisheries Environmental Group (PFEG) postulated that changes in the seasonal behavior and spectral characteristics could be indicators of climate change as well, even without significant changes in the (time-dependent) mean level. For example, when examining long-term time series, researchers often find trends in the winter months that are not apparent

in the summer months. This is not a trend in the overall series mean, but rather is a change in the seasonal cycle. A current research focus of scientists at PFEG, as part of the multinational and multidisciplinary Climate and Eastern Ocean Systems Program, is to examine what constitutes climate change in the ocean through the analysis of environmental variability on long time scales and to note the response of living marine resources to this variability. PFEG scientists are currently examining several physical parameters (for example, wind, SST, surface salinity, and sea level) along the west coast of the Americas using state-space statistical models to separate and describe seasonal patterns and long-term trends in the time series. The models are used to produce nonparametric estimates of trend, nonstationary estimates of the seasonal cycle, and nonstationary spectral estimates. The methodology of the state-space model is briefly explained here along with an example of the output for the La Jolla SST.

Numerous statistical methods are available to remove "noise" (unwanted information) from time series and enhance the signal of interest (for example, by using averaging, spectral filters, and spline fits). One way is to assume that the observed data can be additively decomposed into different components

$$y(t) = T(t) + S(t) + I(t) + E(t), \qquad (1)$$

where $y(t)$ is the observed data, $T(t)$ the trend (time-dependent mean), $S(t)$ the seasonal signal, $I(t)$ the irregular stationary term (which can include autoregressive terms), and $E(t)$ the error, all at time t. As such, the problem is undefined, and typical global approaches might assume that the trend term can be approximated by a given order polynomial or can be described by weighted sums of basis functions, or like assumptions. Another more-local method for making the problem well-defined is to put smoothness constraints on the components. In fitting an unknown functional form to continuous data (such as when smoothing splines are used), one is minimizing a term that trades off the goodness of fit to the data with a smoothness constraint, which usually means that some order of the derivatives are zero. A discrete equivalent is to constrain finite differences or other relevant linear combinations of the components. For a trend, if the finite differences are just constrained, the trend is not allowed to vary. Instead, the finite differences are constrained to be a random variable with a prior distribution of

$$\nabla^k y(t) = e_1 \sim N(0, \sigma_1^2), \qquad (2)$$

that is, the finite differences $[\nabla^k y(t)]$ are a normal random variable with zero mean and variance to be determined. The resulting trend is nonparametric and nonlinear and, because equation (2) is a prior distribution that constrains the smoothness of the trend, these models are referred to as "smoothness priors." Note that if equation (2) is included in the likelihood, then if σ^2 goes to infinity, the fitted trend will exactly interpolate the data (the term in the likelihood is weighted by the inverse of σ^2), while if σ^2 goes to zero, then the data is fit by a k-th order polynomial (for example, for $k = 1$, a straight line trend will be fit).

For the seasonal term of order p, a sum of indicator variables is constrained as

$$\sum_{k=1}^{p} s(t-k+1) = e_2 \sim N(0, \sigma_2^2), \qquad (3)$$

so that the sum of the seasonal indicator variables $[S(t-k+1)]$ is a zero mean normal random variable with a variance to be estimated. If the variance (σ^2) is infinite, the seasonal signal will interpolate the mean deleted data. If the variance is zero, the seasonal cycle is strictly deterministic. For values in between, the seasonal series is nonstationary and nondeterministic. The amplitude, phase, and shape of the series can vary over any 12-month period, the mean of which is approximately zero. (The nonzero mean of the series is included in the trend.) The whole model can be put into state-space form and solved by a combination of Kalman filtering and maximum likelihood.

An example of the various series generated by the model is given in Figure 4. The observed monthly La Jolla water temperature series, with the trend superimposed in bold, is shown in figure 4a. The seasonal and autoregressive (bold) series, plotted on the same scale, are shown in figure 4b. It is clear that the trend includes some interannual variability, such as ENSOs, and decadal and longer-scale trends.

The state-space model is a powerful tool for separating the interannual-to-interdecadal fluctuations in environmental time series from seasonal patterns

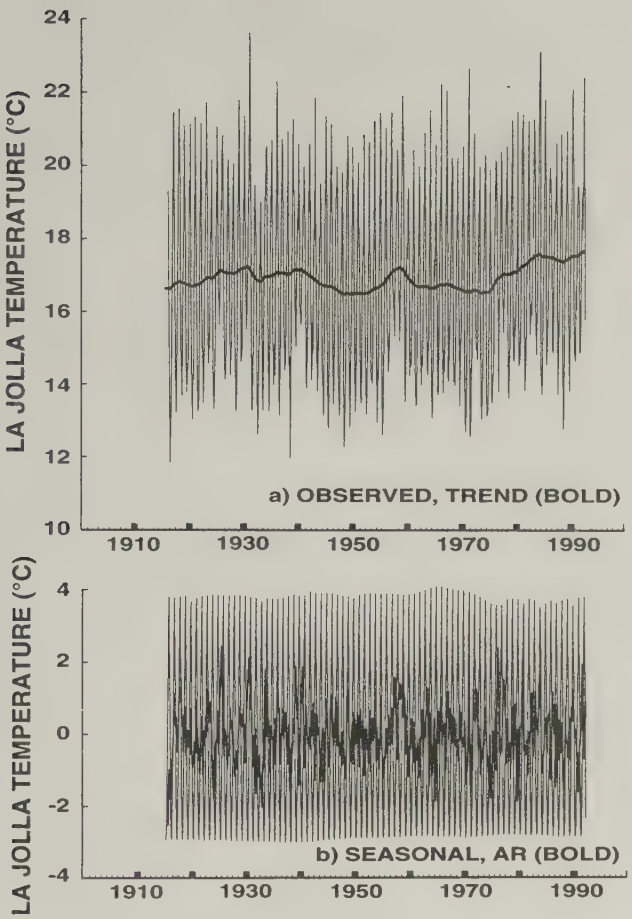

Figure 4. Example of raw monthly and state-space model series for water temperature at Scripps Pier, La Jolla, California, 1916-1992. Observed and trend model (bold) series (a) and seasonal model and autoregressive (bold) series (b).

of variability. The preliminary results show a clear separation of the nonstationary seasonal signal from the nonlinear trend for coastal ocean wind, temperature, salinity, and water level. These results also demonstrate the importance of evaluating temporal and spatial variability over the entire spectrum, rather than simply on global climate scales, when examining long-term rates of ecosystem change.

In future studies, the model will be updated to derive separate estimates of trend and seasonal series common to the entire set (that is, the "global" signal), in contrast to those unique to regions or even individual sites. This will provide a better contrast between truly global/climate changes and regional/ecosystem level environmental fluctuations. The addition of other model terms to estimate the role of phenomena such as ENSO and the quasi biennial oscillation will be considered as well. (R. Mendelssohn and F. Schwing, [408] 656-3311)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

Sixth Annual Consultation of Parties to the South Pacific Regional Tuna Treaty Held in Nadi, Fiji

Mathematical Statistician Al Coan presented a paper titled "Review of the U.S. Purse Seine Fishery for Tropical Tunas in the Western Pacific Ocean, 1993" at the Sixth Annual Consultation of Parties to the South Pacific Regional Tuna Treaty held in Nadi, Fiji, March 7-8, 1994. A meeting of scientists was also held, and a statement from the scientists reviewing the status of skipjack and yellowfin stocks was prepared. Highlights of the paper and discussions at the scientific meetings were as follows.

The 1993 U.S. catch of yellowfin and skipjack tunas in the western Pacific (190,000 metric tons [t]) decreased approximately 10 percent from the 1992 catch (207,100 t). The U.S. fleet in 1993 experienced longer trip lengths and decreases in both number of sets per trip and catch rates than in 1992. However, the ex-vessel value of the 1993 landings increased 9 percent because canneries paid higher prices for the fish and because the slightly larger sizes of fish caught by the fleet brought higher prices.

The scientists at the Consultation considered yellowfin and skipjack tuna stocks in the western Pacific to be healthy and able to sustain increased catches. However, scientists urged caution in expanding the fishery because current analyses do not account for decreasing catch rate trends in the longline fishery and potential interactions between longline and surface fisheries. Status of stock assessments are currently based on tagging studies, and scientists recommended enhancement of current tagging analyses and development of models that can assess stock status through the use of traditional fisheries data instead of high-cost tagging studies.

Local island fishermen were concerned about decreased catch rates and bycatches in their fisheries when the distant-water purse seiners fish in

their Exclusive Economic Zone areas. Current data were not adequate for quantifying the extent and effects of local area depletion and the scientists recommended more research in this area.

Future data collection plans for the western Pacific included greater coverage of basic fisheries data, including bycatch statistics, from all fleets. Collection of other types of biological data that can be used in reproductive and length-weight studies was also recommended. The data will be needed for stock assessment models. (A. Coan, [619] 546-7079)

PELAGIC ECOSYSTEM MODEL DEVELOPMENT PROGRAM

Papers Requested for the 13th Pacific Coast Resource Modeling Conference

The Southwest Fisheries Science Center (SWFSC) is requesting papers for the 13th Pacific Coast Resource Modeling Conference to be held at the University of California, San Diego, July 11-14, 1994. The Conference deals with the complications of movement, migration, dispersal, and spatial heterogeneity in resource assessment and management models. The Conference will deal with the whole range of resource issues and habitats, from marine to terrestrial, and is jointly sponsored by the SWFSC, the Resource Modeling Association, and the San Diego Supercomputer Center.

Inquiries regarding the Conference may be directed to Pierre Kleiber ([619] 546-7076; Internet: pkleiber@ucsd.edu).

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

1992 Billfish Angler Survey Results and 1993 Billfish Tag Report Completed

Analyses of the 1992 Pacific-Indian Ocean International Billfish Angling Survey and the 1993 Cooperative Billfish Tagging Program were completed in February. Results are to be published in the 1994 Billfish Newsletter in April. The Billfish Angler Survey provides the only estimates of billfish angling activities in the Pacific and Indian Oceans. Collection of recreational billfish catch-and-effort data began in 1969 and provides an index of catch-and-effort trends for the recreational fishing community. The recreational fisheries are important economically to many areas of the Pacific. Tourism in places such as Hawaii and Baja California is tremendously enhanced by the presence of billfish sport fishing facilities. Total expenditures disbursed in pursuit of catching a trophy billfish can and has exceeded the value of commercial fisheries operating in adjacent areas.

Trends in the angler catch rates of a particular region may show annual differences resulting from changes in commercial operations or environmental effects. For instance, the decline in the catch rate for striped marlin around the tip of Baja California in the 1970s was shown to be related to extensive commercial longline fishing for marlin and tunas. The subsequent restrictions limiting commercial catches in Mexican waters resulted in increased angler catch rates during the late 1970s. The effects of El Niño-related events also influence the trends in angler catch rates. The cold water episode at the tip of Baja California in 1984 resulted in a decreased rate of success for striped marlin.

Billfish Angler Catch Rates, 1992. Billfish anglers responding to the Billfish Angler Survey for 1992 reported catching 3,751 billfish throughout the Pacific, Indo-Pacific, and Indian Oceans. The total number of days reported fishing for billfish increased 6.4 percent from 1991 to 8,712 days. The catch rate was 0.43 billfish caught per fishing day. This is down about 25 percent from the 1991 catch rate of 0.57 billfish per day but very similar to the 1990 catch rate of 0.42 billfish per day. Highest catch rates for striped marlin were at the southern tip of Baja California, Mexico. Best catch rates for blue marlin were in Hawaii and Tahiti, while black marlin were most readily taken from Australia and New Guinea. The greatest success for sailfish was in the Indian Ocean (Seychelles) and off Costa Rica and Guatemala in the Pacific.

In Table 1, the results of the 1992 survey are given as reported by anglers, by landing locations for the Pacific and Indian Oceans. Included are the fishing area; number of angler days; number of billfish caught, catch-per-unit effort in terms of fish per day; and the major species reported. For comparison, the 1991 figures are shown in parentheses.

Billfish Tagging Results, 1993. Billfish tagging reports received indicate a total of 1,153 billfish were tagged and released in 1993, a 35 percent

Table 1. Results of 1992 Billfish Angler Survey. Data in parentheses are values recorded in 1991.

	ANGLER FISHING DAYS	BILLFISH PER FISHING DAY (CPUE)	MAJOR SPECIES
PACIFIC OCEAN			
S. California	2,220 (2,107)	0.12 (0.06)	striped marlin
Hawaii	3,379 (1,892)	0.28 (0.38)	blue marlin
Baja California, Mexico	1,240 (1,952)	0.60 (0.46)	striped marlin
Mazatlan, Mexico	23 (143)	0.95 (0.87)	sailfish
Manzanillo, Mexico	28 (69)	0.61 (0.32)	sailfish
Puerto Vallarta, Mexico	42 (22)	0.53 (0.68)	sailfish
Acapulco, Mexico	79 (89)	0.90 (1.03)	sailfish
Guamas, Mexico	37 (73)	0.46 (0.22)	sailfish
Guatemala	334 (232)	1.37 (1.37)	sailfish
Costa Rica	234 (288)	2.03 (2.33)	sailfish
Panama	38 (64)	1.97 (2.69)	sailfish
Peru	115 (5)	0.41 (0.40)	striped marlin
Guam, U.S.A.	102 (164)	0.28 (0.73)	blue marlin
Tahiti, French Polynesia	83 (104)	0.47 (0.38)	blue marlin
Fiji	51 (24)	0.14 (0.12)	blue marlin
New Zealand	143 (275)	0.06 (0.92)	striped marlin
Australia	213 (204)	0.54 (0.42)	black marlin
INDO-PACIFIC			
Micronesia	7 (1)	0.43 (-)	blue marlin
New Guinea	30 (90)	0.63 (0.14)	black marlin
Malaysia	35 (23)	0.09 (0.04)	blue marlin
Thailand	2 (8)	0.50 (0.12)	sailfish
Hong Kong (Pratas)	31 (20)	0.03 (-)	blue marlin
INDIAN OCEAN			
Kenya	142 (219)	1.04 (1.37)	sailfish
Mauritius	11 (48)	0.09 (0.40)	blue marlin
Seychelles	43 (-)	4.54 (-)	sailfish

increase over 1992. Billfish anglers tagged 952 billfish while commercial swordfish/tuna longliners operating out of Hawaii tagged 187 billfish (mostly small swordfish). Fourteen billfish were tagged and released from NMFS research ships.

Fourteen billfish tags were returned in 1993. Two were from blue marlin, eight from striped marlin, one from a swordfish, and one each from a yellowfin tuna, a bigeye tuna, and a blue shark. Both blue marlin were at liberty less than 90 days and had traveled only short distances. Of the striped marlin tagged in southern California waters, one traveled in excess of 2,000 miles from near Santa Barbara Island, California, to just northeast of the Island of Maui in 214 days. Another striped marlin tagged near Avalon, Santa Catalina Island, traveled 900 miles south to the East Cape area of Baja California in 144 days. Other striped marlin recoveries in and around the Hawaiian Islands indicate significant inter-island movement. The swordfish tagged in the North Pacific was at liberty a full year but only had a net movement of 321 miles.

Response to the Billfish Angler Survey and participation in the Billfish Tagging Program are voluntary and tagging supplies are available at no cost to billfish anglers from the SWFSC. (D. Holts, [619] 546-7186)

TIBURON LABORATORY

Tiburon, California

GROUNDFISH COMMUNITIES INVESTIGATION

Analysis of the First and Second Annulus from Lingcod Fin Rays Completed

Management of lingcod, *Ophiodon elongatus*, has relied heavily on age-structured models based on ages estimated from fin ray sections and so has suffered from long-standing uncertainty regarding the first and second annuli in these structures. To resolve this problem, Fishery Biologists Pete Adams, Tom Laidig, and Kelly Silberberg have completed an analysis using lingcod fin rays of known ages treated with oxytetracycline.

They worked with fin rays from a variety of sources. Material from a large number of first-year individuals taken in central California during 1993 (by midwater trawl, bottom trawl, and spear fishing) and from specimens reared in the laboratory provided the basis for a growth curve (Fig. 1) that indicated lingcod at age 1 are larger than 220 millimeter (mm) total length (TL). Additional data from the captive lingcod had determined that lingcod at age 2 are between 340 and 500 mm TL (Fig. 2). Based on this knowledge, they assembled a series of fin rays determined with reasonable assurance (on the basis of body length) to be 1 and 2 years old. With this material they were able to examine the fin ray sections

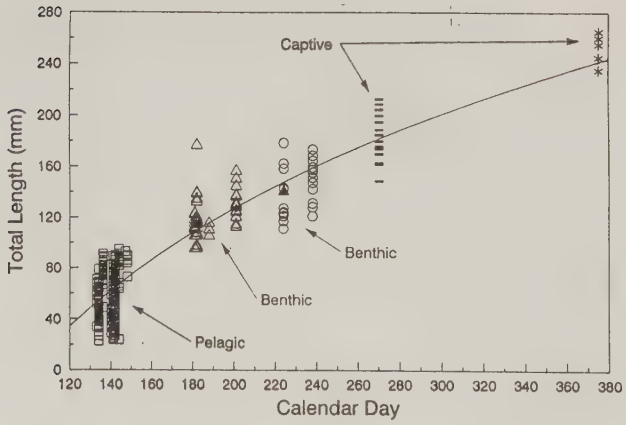

Figure 1. Lengths of young-of the-year lingcod captured off central California and lab reared in 1993.

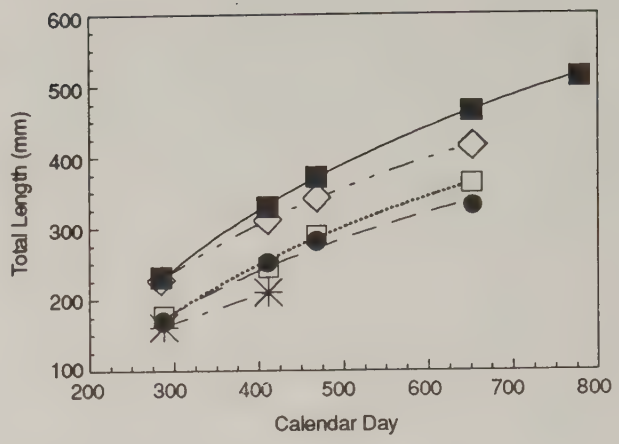

Figure 2. Growth of five captive lingcod.

with the intent of determining the reliability of the first and second annuli as age indicators. First, they measured the distance from the ray's center to each complete ring, along with the ray's radius. Their examination consistently revealed one ring in the 1-year fish, and two in the 2-year fish (Figs. 3 and 4). It was concluded that these rings are the first and second annuli. The first annulus occurred approximately 0.3 to 0.5 mm from the center of the ray, the second approximately 0.45 - 0.70 mm. There was a positive correlation of annulus size and fin ray radius, so that the annuli were small when the radius was small.

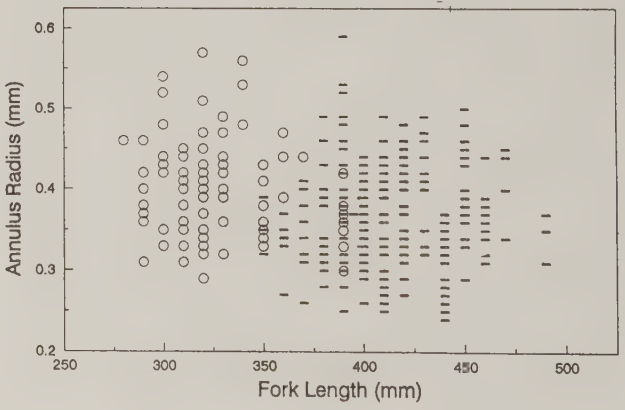

Figure 3. Radius of the first annuli from 1- and 2-year-old lingcod. Open circles are for 1-year-old lingcod and dashes are for 2-year-old lingcod.

The results of additional study of 375 lingcod of various lengths (280-1,300 mm) collected during 1992 were consistent with these findings. These results should provide increased confi-

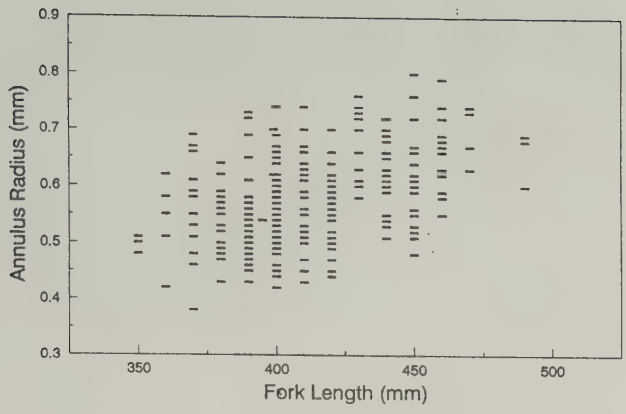

Figure 4. Radius of the second annuli from 2-year-old lingcod.

dence in existing estimates of lingcod ages. (P. Adams, T. Laidig, and K. Silberberg, [415]435-3149)

GROUNDFISH ANALYSIS INVESTIGATION

Diel Variation in Bongo Net Catchability Studied

Ichthyoplankton surveys can be used to estimate egg and larval production rates and, in conjunction with information on adult reproductive biology, the biomass of the spawning stock. Typically, ichthyoplankton surveys are conducted with plankton nets, especially the standard dual-sided bongo net. However, to be useful in estimating stock egg and larval production rates, an unbiased estimate of the total number of eggs and larvae in the water column must be obtained. If the catchability of eggs and larvae is other than 1.0, depending on extrinsic environmental factors (for example, time of day), then adjustments must be made to the raw data to accurately reflect true abundance patterns of the ichthyoplankton population sampled.

A bongo net survey directed at shortbelly rockfish, *Sebastes jordani*, larvae was fielded in February 1991 with the intention of estimating the production rate of day-0 larvae in the region bounded by Point Reyes and Monterey Canyon, California. A total of 152 bongo stations were occupied over a 6½-day period (Fig. 5). The larvae were sorted and a subsample was aged to estimate age-specific abundances at each station occupied.

To test whether the bongo net's catchability of shortbelly rockfish larvae depended on the particular time of day when the tow was completed, an analysis of variance (ANOVA) was conducted. The

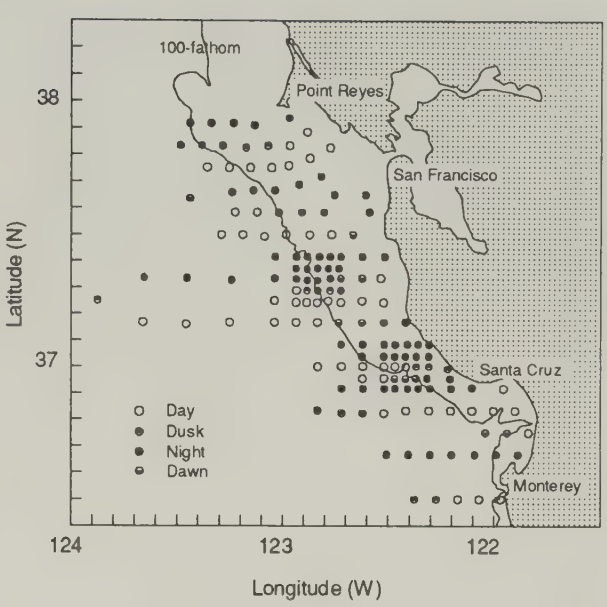

Figure 5. Map showing the locations of net bongo sampling stations, off California in February 1991 for shortbelly rockfish larvae.

dependent variable in the model was $\log_e$ [number/10 m^2 + 1]. The independent variables in the model were (1) larval age class, (2) bottom depth interval, and (3) diel time of day. Larval age was categorized into four age classes (0-2 days [d], 3-9 d, 10-19 d, and > 20 d), while bottom depths were binned into four intervals (< 120 m, 120-300 m, 300-600 m, and > 600 m). Prior work had shown that both factors substantially influence the catch rate of shortbelly rockfish larvae. In the ANOVA, time of day was classified into day, dusk, night, and dawn, with the two crepuscular periods defined as ± 1 hour around sunset and sunrise (Fig. 5). In addition to the three main effects, the ANOVA initially included all first-order interaction terms.

Results showed (Table 1) that all three main effects had a significant influence on the larval catch rate. In addition, two of three first-order interaction terms were significant, although the interaction between period and age was not significant. This implies that when adjusted for depth effects, older larvae have the same diel variation in catch rates as young larvae, a somewhat surprising result. Even so, the existence of a diel period effect indicates that catchability of shortbelly rockfish is not constant and that larval catch rates are biased estimates of absolute abundance.

To correct for the diel effect on bongo net catchability, the least-square means for the period factor

Table 1. Analysis of variance testing the effect of time of day (period) on the catch rate of larval shortbelly rockfish. Other main effects are age class and depth interval. Larvae collected from bongo nets off California, from Point Reyes to Monterey, in February 1991.

Source	DF	F Value	Pr > F
Model	35	4.87	0.0001
Error	564		
Corrected Total	599		
Period	3	7.60	0.0001
Age	3	11.27	0.0001
Depth	3	5.35	0.0012
Period*Age	9	0.68	0.7307
Age*Depth	9	2.06	0.0310
Period*Depth	8	2.36	0.0166

were calculated after refitting the model with non-significant terms omitted. The difference in means between night and day was then used to adjust all day catches upwards to account for daytime avoidance (period effects crossed with depth were ignored). This correction amounted to approximately 50 percent, that is, daytime catch rates are about 2/3 nighttime catch rates. Due to the small number of samples gathered during dawn (n = 11) and dusk (n = 15), correction factors for the two crepuscular periods were calculated by simple linear interpolation over the 2-hour transition interval. It is of interest to note, however, that the dawn least-square mean was considerably higher than the others, suggesting minimal net avoidance at that time. Conversely, these findings suggest that substantial net avoidance can occur at other times, including the night. While intriguing, these results require further study, particularly since there was fine-scale temporal and spatial confounding of the data (Fig. 5). Task members are exploring the possibility of gaining a better understanding of diel variability in larval catch rates in the coming year through field sampling. (S. Ralston, [415] 435-3149)

GROUNDFISH PHYSIOLOGICAL ECOLOGY INVESTIGATION

Study Initiated to Determine the Reproductive Physiology of Shortbelly Rockfish

The shortbelly rockfish, *Sebastes jordani*, is a dominant component of the fish community in the California Current ecosystem off central California. These fish are important forage for marine mammals, seabirds, and commercially important fish species. Since they are not utilized in any fishery, studying the species offers the opportunity to determine reproduction and the influences of physiological and environmental factors on reproductive success of an unexploited population.

The Groundfish Physiological Ecology Investigation has begun studying shortbelly rockfish populations located at three submarine canyons--Ascension, Pioneer, and Bodega--within the area that represents the center of this species' distribution. The study is designed to last at least 3 to 5 years in order to evaluate yearly variability in reproduction and environmental conditions. Shortbelly rockfish collection for the current reproductive season, which starts in November and ends in April, has begun. Specimens have been obtained from early December and early and late January using a contracted fishing vessel from Santa Cruz, *Good News*. Further collections will be made from *Good News* and the NOAA ship *David Starr Jordan* in February, March, and April. Adult rockfish are collected by trawl and larvae by bongo nets.

The study is designed to measure qualitative and quantitative aspects of adult reproductive success, environmental variation, and the physiological condition of pelagic larvae. These data, along with larval abundance estimates from Groundfish Analysis scientists working jointly on the collection trips, will be compared to physiological status and abundance estimates of juvenile shortbelly rockfish from the annual May-June survey. The results will determine the interrelationships among adult, larval, and environmental variables and their effects on year-class strength of juveniles. Additionally, age-specific reproductive success of adults can be evaluated.

The analyses performed on adults will include morphometry, age, fecundity, nutritional energetics, and image analysis of eggs and embryos. Pelagic larvae will be measured (length), separated by stage of development (oil globule present, pre-flexion, post-flexion), and analyzed for protein, lipid class distribution, and water content.

During all collections, temperature data will be obtained (1) at the depth of collection by deploying a TDR (temperature-depth recorder) with the net and (2) by depth from a conductivity-temperature-density (CTD) apparatus deployed after each successful trawl. The CTD will also record photosynthetically available radiation and salinity. Current profile data collected on the *David Starr Jordan* will be acquired by the acoustic Doppler current profiler. To complete the environmental

data, upwelling indices for 36° and 39° N, sea level anomalies, and sea-surface temperature (from satellite images) will be added to computer files. (B. MacFarlane, [415] 435-3149)

INFORMATION TECHNOLOGY SERVICES

Software and Services on the La Jolla LAN Summarized

Network services on the La Jolla local area network (LAN) have been divided into two categories for the purpose of this summary. The first includes those services provided under the umbrella of the Microsoft's Network Operating System "LAN Manager." The second includes transmission control protocol/internet protocol (TCP/IP) services which provide users the ability to log in to remote "host" computers, make file exchanges, and access electronic mail using the Simple Network Mail Protocol.

LAN Manager has been configured at La Jolla to provide a wide array of shareable computer programs or "applications." With the sole exception of cc:Mail, all LAN Manager applications must be run on DOS or OS/2-networked PCs (as opposed to Macintosh or UNIX computers). The following applications are currently available under LAN Manager:

Two word processing programs are available. These include WordPerfect 5.1 and Wordstar 4.0 for DOS. WordPerfect is the NMFS wordprocessing "standard" and has been offered at La Jolla in some version since the network was installed in 1988. Initially, WordPerfect version 4.2 was offered. As newer versions became available, the network version was updated. The network is currently serving only WordPerfect version 5.1. WordPerfect 6.0 for DOS has been installed and is presently being tested in preparation for its general release. WordPerfect is one of the most widely used network applications.

Usage of the second word processor, Wordstar 4.0, has been limited on the Southwest Fisheries Science Center (SWFSC) network since it doesn't conform to the NMFS WordPerfect standard. Many La Jolla staff who write substantial computer programs find Wordstar's block and column operations better than those available in WordPerfect. As a result, WordStar is used at La Jolla primarily as a text editor in developing computer programs.

Three Database Management System (DBMS) applications are currently available. These include dBASE III+, FoxPro 2.0, and FoxPro 2.5. These DBMSs provide users with the capability to create private database applications and manipulate database files. Available as shareable applications, they allow access by users to data stored on their own PC disks or on shared network disks. They have been used by Information Technology Services to develop certain custom SWFSC network applications such as the Financial Reporting System.

Borland's Quattro Pro 4.0 for DOS, SYSTAT 5.03, and Procomm communications software are currently available. Borland's Quattro Pro 4.0, a single spreadsheet program, can be run by typing QPRO at the network prompt. SYSTAT, an integrated statistical application, includes special facilities for (1) complex data manipulations, (2) graphics, and (3) statistical computations. Procomm communications software provides terminal emulations and modem handling for users having locally attached modems.

cc:Mail is the LAN's electronic mail (e-mail) package. cc:Mail gives La Jolla users the ability to exchange e-mail with users at NMFS sites throughout the country. NMFS cc:Mail Post Offices are interconnected through a series of gateway machines which use modems to deliver e-mail between sites on an unattended basis. The La Jolla cc:Mail application includes a handy "user directory," which provides automatic addressing to NMFS cc:Mail users around the country and to many individuals on Internet mail and the NOAA-wide Banyan Mail network (for example, Western Administrative Support Center and National Ocean Service in Seattle).

A mailing label and envelope manager application, Envelope Manager, is available. The application uses databases of addressees to make large mailings more manageable and provides advanced features that conform to U.S. Post Office requirements, including bar-coding of zip codes, which results in discounted mailing costs.

A NOAA-wide electronic telephone book, the NOAA Locator, is available, which includes the names of all NOAA employees. It is updated by NOAA on a quarterly to biannual basis and includes employee names, agency mail codes, telephone numbers, and mailing addresses.

The network also runs a number of special applications which have a limited user base and are not directly relevant to most network users. These applications are used for the most part by staff in the Lab's Administrative Support Group. The applications take advantage of shared datasets, nightly tape backups, and the LAN's database application software. The applications include systems in the area of property management, procurement, and personnel.

In many cases, user access to a LAN Manager network application must be "enabled" and individually configured prior to use. This frequently involves software installation on the user's workstation and configuration on the server side of the network.

TCP/IP software currently running on the La Jolla LAN includes, but is not limited to, the following:

Many PCs are using the National Center for Supercomputer Applications (NCSA) public-domain (free) versions of Telnet (for remote log ins) and File Transfer Protocol (FTP). NCSA is funded under the auspices of the National Science Foundation. NCSA TCP/IP software enables remote host log ins from La Jolla's network-connected PCs. These hosts are frequently located in the La Jolla Lab, but they can be situated virtually anywhere on the Internet. Once logged in, La Jolla users can control remote hosts, running host software and otherwise utilizing the host system's resources. FTP file transfers between TCP/IP host machines and PC clients constitute another important service between the two.

X-terminal emulation software provides an integrated visual interface to many UNIX systems. This software can be specially configured on the networked PC to simplify operations and customize application interfaces. X-terminal "mail-tool" programs are very helpful in taming the notoriously difficult UNIX mail command-line interface.

Offline electronic mail readers, such as Northwestern University's popmail (NUPOP), also offer a simplified e-mail interface for PC users accessing their e-mail on a UNIX mail host. Eudora is an offline mail reader much like NUPOP. Eudora has a very nice Macintosh version which offers Macintosh users a simple interface to their UNIX e-mail. Both Eudora and NUPOP are public-domain software.

Gopher programs, such as PC Gopher and TurboGopher for Macintosh, are also public-domain software. These programs provide users with a visual "browser" interface to navigate the sometimes confusing paths of the Internet. They provide a built-in FTP service which is used to download useful files when they are encountered. Windows Mosaic and Mosaic for Macintosh are similar to Gopher programs and also provide "browser" capabilities to make it easier to access information and acquire files from the Internet.

Finally, USENET news reader software provides networked Macintoshes and PCs with the ability to easily connect to USENET news servers. These machines offer topical forums for discussions on literally thousands of different topics including the sciences and computer technology. (F. Ralston, [619] 546-7062)

PUBLICATIONS

Published

Ainley, D. G., W. J. Sydeman, R. H. Parrish, and W. H. Lenarz. 1993. Oceanic factors influencing distribution of young rockfish (*Sebastes*) in central California: A predator's perspective. Calif. Coop. Oceanic Fish. Invest. Rep. 34:133-139.

The diet of a seabird, the Common Murre, *Uria aalge*, was used to assess the abundance of juvenile rockfish (*Sebastes* spp., mostly *S. jordani*) in the Gulf of the Farallones, California, 1973-90. On the basis of an exploratory analysis of the data and of several oceanographic factors, the researchers hypothesized that availability of fish in the study area during June-July was a function of advection during the January-February period of rockfish parturition. When upwelling or downwelling was persistent in winter, there were few juveniles in late spring, but when upwelling had been mild or pulsed, juveniles were abundant. Rockfish availability also decreased when turbulence, sea level, and sea-surface temperature were high during winter. Stepwise multiple regression analyses indicated that, among these variables, advective transport significantly affects the distribution of juvenile rockfish.

Akin, P. A., K. M. Peltier, and R. B. Miller. 1993. Techniques for the preparation and examination of reproductive samples collected from dolphins in the eastern tropical Pacific. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-192, 48 p.

Aguirre, A. Alonso, G. H. Balazs, B. Zimmerman, and F. D. Galeys. 1994. Organic contaminants and trace met-

als in the tissues of green turtles (*Chelonia mydas*) afflicted with fibropapillomas in the Hawaiian Islands. Mar. Pollut. Bull. 28(2):109-114.

Environmental contaminants have been listed as a possible cause of green turtle fibropapillomas (GTFP). Brain, fat, liver, and kidney tissues from 10 juvenile green turtles, *Chelonia mydas*, afflicted with GTFP were tested to determine exposure to selected environmental pollutants and any possible relation to GTFP. One juvenile green turtle free of the disease, one pelagic green turtle, and one pelagic loggerhead turtle, *Caretta caretta*, served as controls. Egg shells and tissues from three green turtle hatchlings were also tested. The tissues and shells analyzed in this study indicated that none contained any of the listed organochlorine, polychlorinated biphenyl, organophosphate, or carbamate insecticides in concentrations above the stated method of detection limits. Most of the concentrations of selenium and heavy metals were also considered to be below levels reported normal in other animal species. No correlation was found between the contaminants tested and GTFP because of the low levels detected. Trace metals and other pollutants tested in this study play a minor role in the aetiology of GTFP in a discrete green turtle population at Kaneohe Bay, Island of Oahu, Hawaii.

Alcorn, D. J., and R. L. Westlake. 1993. The Hawaiian monk seal on Laysan Island, 1986. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-191, 24 p.

Balazs, G. H. 1994. Homeward bound: Satellite tracking of Hawaiian green turtles from nesting beaches to foraging pastures. *In* Schroeder, B.A., and B.E. Witherington (comps.), Proceedings of the Thirteenth Annual Symposium on Sea Turtle Biology and Conservation, February 23-27, 1994, Jekyll Island, Florida, p. 205-208. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-341.

Balazs, G. H., R. K. Miya, and M. A. Finn. 1994. Aspects of green turtles in their feeding, resting, and cleaning areas off Waikiki Beach. *In* Schroeder, B.A., and B.E. Witherington (comps.), Proceedings of the Thirteenth Annual Symposium on Sea Turtle Biology and Conservation, February 23-27, 1994, Jekyll Island, Florida, p. 15-18. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-341.

Bigelow, K. A. 1994. Age and growth of the oceanic squid, *Onychoteuthis borealijaponica*, in the North Pacific. Fish. Bull., U.S. 92:13-25.

Boehlert, G. W., and B. C. Mundy. 1993. Ichthyoplankton assemblages at seamounts and oceanic islands. Bull. Mar. Sci. 53(2):336-361.

Seamounts and oceanic islands support demersal or neritic fish populations and are localized sources of eggs and larvae added to a background of oceanic ichthyoplankton. Associated larval assemblages, however, have been identified in few studies, and most have been based on subjective classifications of species by reproductive characteristics. At seamounts, little evidence exists that ichthyoplankton assemblages differ from the background field despite physical mechanisms proposed to maintain planktonic forms. Larvae of bottom-associated species are notably rare in samples taken in these regions. In contrast, characteristic ichthyoplankton assemblages have been described at oceanic islands. Unique assemblages may exist in embayments and lagoons, but they are not well described. Nearshore assemblages (0-0.5 km offshore) are dominated by larvae of small species with demersal eggs; neritic assemblages (0.5 to 3-5 km offshore) include inshore species with demersal and planktonic eggs mixed with larvae of certain species that are usually oceanic as adults. Although larvae of some inshore species with pelagic eggs are found offshore in oceanic assemblages (beyond 3-5 km), assemblages there are poorly described. Spatial and seasonal spawning behavior of adults plays the key role in formation of ichthyoplankton assemblages. Mechanisms that may maintain ichthyoplankton assemblages at islands include boundary layers, small-scale frontal dynamics, tidal currents, topographically produced eddies, seasonally reduced or variable currents, and regions of no or returning flow. Larval behavior, particularly that affecting vertical distribution, can modify the influences of these mechanisms. The integrity of assemblages can be disrupted by both biotic and abiotic factors.

Boehlert, G. W., C. D. Wilson, and K. Mizuno. 1994. Populations of the sternoptychid fish *Maurolicus muelleri* on seamounts in the central North Pacific. Pac. Sci. 48(1):57-69.

The lightfish, *Maurolicus muelleri* (Gmelin), is a cosmopolitan sternoptychid fish most abundant near continental shelf-slope breaks and rare in the open ocean. Recent studies have documented dense populations on seamounts of the South Atlantic and North Pacific. At Southeast Hancock Seamount, a small guyot in the central North Pacific, *M. muelleri* populations are mainly composed of juveniles. Seasonal length frequencies suggest that recruitment at sizes greater than 20 mm standard length (SL) occurs principally in spring and summer months, with growth over summer and fall coincident with decreasing abundances. Mature fish in reproductive condition occur in winter months but do not survive to the following spring; they also may be too few at this small seamount to support annual recruitment. Potential sources of additional recruitment include populations at several larger seamounts in the southern Emperor group and also the large populations around Japan. Advection of eggs and larvae in the Kuroshio Extension may provide recruits for dependent populations at the seamounts. Mean current flow and satellite drifters suggest a transit time of 100–200 days from the coast of Japan to the region of the seamounts; estimates of age at length suggest that smaller fish have similar ages at recruitment. Gill-raker counts, however, differ

between Japanese and seamount populations. The researchers suggest that the southern Emperor Seamount populations serve as the source for replenished annual recruitment to the small population at Southeast Hancock Seamount.

Brill, R. W., and D. B. Holts. 1993. Effects of entanglement and escape from high-seas driftnets on rates of natural mortality of North Pacific albacore, *Thunnus alalunga*. Fish. Bull., U.S. 91:798-803.

Brill, R. W., D. B. Holts, R. K. C. Chang, S. Sullivan, H. Dewar, F. G. Carey. 1993. Vertical and horizontal movements of striped marlin (*Tetrapturus audax*) near the Hawaiian Islands, determined by ultrasonic telemetry, with simultaneous measurement of oceanic currents. Mar. Biol. 117:567-574.

Cailliet, G. M., D. B. Holts, and D. Bedford. 1993. A review of the commercial fisheries for sharks on the west coast of the United States. *In* Pepperell, J., J. West, and P. Woon (eds.), Shark Conservation, p. 13-29. Proceedings of an International Workshop on the Conservation of Elasmobranchs held at Taronga Zoo, Sydney, Australia, February 24, 1991.

Six species presently dominate commercial fisheries for sharks off the western United States. The oldest of these fisheries (for soupfin shark, *Galeorhinus galeus*) was decimated in 1944 but has persisted for the past two decades on a small scale, averaging between 150,000 and 250,000 pounds (~68-114 metric tons [t]) annually. The largest (for spiny dogfish, *Squalus acanthias*) has consistently produced landings in excess of 5 million pounds (~2273 t) annually. The blue shark, *Prionace glauca*, fishery, in operation experimentally between 1979 and 1980, now is part of a longline fishery targeting common thresher shark, *Alopias vulpinus*, and shortfin mako shark, *Isurus oxyrinchus*. Declines in catches and size composition of the common thresher fishery have required serious management actions such as time/area closures, permit limitations, and low total allowable landings. The shortfin mako shark fishery has not seriously declined but takes only 1-, 2- and sometimes 3-year-old sharks. Landings of Pacific angel sharks, *Squatina californica*, in a localized bottom gill net fishery peaked in 1985 and 1986 at 1.2 million lbs (~546 t) annually but drastically declined due to decreased availability and alternative sources of low-cost imported shark meat. The leopard shark, *Triakis semifasciata*, another common inshore species, is fished both recreationally and commercially, with its landings fluctuating between 18,000 and 100,000 pounds (~8-46 t) per year, with no significant decline. Thus, total west coast shark landings increased steadily through 1985 but have since declined. Declines have occurred mainly because slow growth, low fecundity, and late age at maturity make elasmobranchs vulnerable to overfishing.

DiNardo, G. T. 1993. Statistical guidelines for a pilot observer program to estimate turtle takes in the Hawaii longline fishery. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-190, 40 p.

Eldridge, M. B. 1994. Hook-and-line fishing study at Cordell Bank, California, 1986-1991. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-197, 24 p.

Hook-and-line landings at the marine bank, Cordell Bank, California, were identified and quantified from 1986-1991. A total of 45 charter cruises were conducted in which an average of 11.5 anglers expended 3.9 hours fishing. The mean vessel catch per trip was 162 fish landed, resulting in a total catch of 7,439 fish during the entire study. No annual pattern to the catch-per-unit effort was apparent, while interannual differences were found. Twenty-eight different fish species were identified during the study; a mean of 15.3 species per trip was observed. Rockfishes, genus *Sebastes*, dominated the catches, comprising over 80 percent of all landings. Yellowtail rockfish, *S. flavidus*, the target species of the research effort, made up 47.9 percent of the total catch. Sex ratios of the yellowtail rockfish exhibited an annual pattern, but the overall annual ratio was even. In comparison with coastwide landings, Cordell Bank was found to be a consistently productive fish habitat that supported a diverse fish community.

Gilpatrick, J. W., Jr., and M. S. Lynn. 1994. A test of two photogrammetric measuring instruments used to determine dolphin lengths from vertical aerial photographs. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-196, 14 p.

Hanan, D. A., D. B. Holts, and A. L. Coan, Jr. 1993. The California drift gill net fishery for sharks and swordfish, 1981-82 through 1990-91. Calif. Dept. Fish and Game, Fish Bull. 175, 95 p.

California's drift gill net fishery developed rapidly in the late 1970s off southern California. The fishery operates primarily between San Diego and Cape Mendocino and concentrates on swordfish in the Southern California Bight during May to December. It originally targeted the common thresher shark, *Alopias vulpinus*, but swordfish, *Xiphias gladius*, and shortfin mako shark, *Isurus oxyrinchus*, became important components of the catch. Data from the California logbook system, landing receipts, and market samples were summarized over 10 fishing seasons. During this period, the fishery evolved from a small nearshore experiment to a major California fishery. Significant changes in nearly every aspect of the fishery occurred including boats and gear, techniques and regulations, fishing areas and seasons, and targeted species. During the period studied, fishing effort fluctuated from a high of 11,000 sets to a low of about 4,000 sets and this decrease in effort corresponds to a decrease in total landings of approximately the same proportions. Decreases in landings of common thresher were over 80 percent, while swordfish and shortfin mako landings decreased 60 and 40 percent, respectively. Aver-

age sizes of swordfish showed no change. Average sizes of shortfin mako decreased approximately 40 percent from the 1982-83 through the 1985-86 fishing season but rebounded during the 1989-90 season. Average sizes of common thresher, however, decreased 30 percent from the 1982-83 season and remained low. This may indicate a decline in the common thresher stock or reflect changes in the season and area of fishing operations.

This publication also addresses some conflicts occurring during the first 10 years of the fishery as well as bycatch of other fishes.

Huppert, D. D., and T. W. Mittleman. 1994. Economic effects of the United Nations moratorium on high seas driftnet fishing. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-194, 62 p.

Lee, T. 1994. Report on cetacean aerial survey data collected between the years of 1974 and 1982. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-195, 62 p.

Miyazaki, N., and W. F. Perrin. 1994. Rough-toothed dolphin—*Steno bredanensis* (Lesson, 1828). *In* Ridgway, S. R., and R. Harrison (eds.), Handbook of Marine Mammals, Volume 5: The First Book of Dolphins, p. 1-22. Academic Press, N.Y.

Moffitt, R. B. 1993. Deepwater demersal fish. *In* Wright, A., and L. Hill (eds.), Nearshore marine resources of the South Pacific, p. 73-95. Institute of Pacific Studies, Suva, Fiji.

Perrin, W. F., D. K. Caldwell, and M. C. Caldwell. 1994. Atlantic spotted dolphin—*Stenella frontalis* (G. Cuvier, 1829). *In* Ridgway, S. R., and R. Harrison (eds.), Handbook of Marine Mammals, Volume 5: The First Book of Dolphins, p. 173-190. Academic Press, N.Y.

Perrin, W. F., and J. W. Gilpatrick, Jr. 1994. Spinner dolphin—*Stenella longirostris* (Gray, 1828). *In* Ridgway, S. R., and R. Harrison (eds.), Handbook of Marine Mammals, Volume 5: The First Book of Dolphins, p. 99-128. Academic Press, N.Y.

Perrin, W. F., and A. A. Hohn. 1994. Pantropical spotted dolphin—*Stenella attenuata*. *In* Ridgway, S. R., and R. Harrison (eds.), Handbook of Marine Mammals, Volume 5: The First Book of Dolphins, p. 71-98. Academic Press, N.Y.

Perrin, W. F., S. Leatherwood, and A. Collet. 1994. Fraser's dolphin—*Lagenodelphis hosei* Fraser, 1956. *In* Ridgway, S. R., and R. Harrison (eds.), Handbook of Marine Mammals, Volume 5: The First Book of Dolphins, p. 225-240. Academic Press, N.Y.

Perrin, W. F., and J. G. Mead. 1994. Clymene dolphin—*Stenella clymene* (Gray, 1846). *In* Ridgway, S. R., and R. Harrison (eds.), Handbook of Marine Mammals, Volume 5: The First Book of Dolphins, p. 161-172. Academic Press, N.Y.

Perrin, W. F., C. E. Wilson, and F. I. Archer II. 1994. Striped dolphin—*Stenella coeruleoalba* (Meyen, 1833). *In* Ridgway, S. R., and R. Harrison (eds.), Handbook of Marine Mammals, Volume 5: The First Book of Dolphins, p. 129-160. Academic Press, N.Y.

Perryman, W. L., D. W. K. Au, S. Leatherwood, and T. A. Jefferson. 1994. Melon-headed whale—*Peponocephala electra* Gray, 1846. *In* Ridgway, S. R., and R. Harrison (eds.), Handbook of Marine Mammals, Volume 5: The First Book of Dolphins, p. 363-386. Academic Press, N.Y.

Perryman, W. L., and M. S. Lynn. 1994. Examination of stock and school structure of striped dolphin (*Stenella coeruleoalba*) in the eastern Pacific from aerial photogrammetry. Fish. Bull., U.S. 92(1):122-131.

Determination of stock structure for striped dolphins, *Stenella coeruleoalba*, in the eastern Pacific has been problematic because few specimens have been available for study. The researchers compared length data obtained from vertical aerial photographs of 28 schools of striped dolphins from the northern and southern regions of the eastern tropical Pacific and found no significant differences in average length for adult females (180 cm) or for adult females, defined here as dolphins closely accompanied by a calf. Analyses of back-projected birth dates for dolphins 155 cm revealed a broad pulse in reproduction extending from the fall through the spring; however, sample size was inadequate to compare timing of reproduction between the two areas. Striped dolphins measured from aerial photographs were longer on average than those killed incidentally by fishing operations. The researchers found a pattern of segregation by size between schools of juveniles and adults that are found in the western Pacific. They hypothesized that the specimen database may be biased because tuna purse seine fishermen in the eastern tropical Pacific may selectively set on schools composed of younger, smaller dolphins.

Polovina, J. 1994. The case of the missing lobsters. Nat. Hist. 103(2):50-59.

Polovina, J. J., and G. T. Mitchum. 1994. Spiny lobster recruitment and sea level: results of a 1990 forecast. Fish. Bull., U.S. 92(1):203-205.

Polovina, J. J., G. T. Mitchum, N. E. Graham, M. P. Craig, E. E. DeMartini, and E. N. Flint. 1994. Physical and biological consequences of a climate event in the central North Pacific. Fish. Oceanogr. 3(1):15-21.

Climatic changes over the North Pacific which began in the mid 1970s, peaked in the early 1980s, and ended by the late 1980s, appear to have altered productivity at various trophic levels in the marine ecosystem in the central North Pacific. The climatic change resulted in increased mixed layer depth and the frequency of deep mixing events, particularly during January-March. A number of biological time series for species ranging from primary to apex levels in the Northwest-

ern Hawaiian Islands, show corresponding declines in productivity of 30-50 percent from the early 1980s to the present. The authors hypothesize that during the early 1980s, increased mixing due to the climate event resulted in greater nutrient input into the euphotic zone and ultimately increased ecosystem productivity. Productivity over a range of trophic levels declined when the climate event ended.

Seki, M. P., and K. A. Bigelow. 1993. Aspects of the life history and ecology of the Pacific pomfret *Brama japonica* during winter occupation of the subtropical frontal zone. *In* Ito, J., et al. (eds.), INPFC Symposium on biology, distribution, and stock assessment of species caught in the high seas driftnet fisheries in the North Pacific Ocean, Bulletin Number 53 (II), p. 273-283. Int. North Pac. Fish. Comm., Vancouver, Canada.

One of the most widely distributed and abundant nektonic animals in the epipelagic North Pacific Ocean is the Pacific pomfret, *Brama japonica*. Various ecological and life history aspects of *B. japonica* are presented, which are based on 148 larval and juvenile specimens collected with a midwater trawl at eight locations north of the Hawaiian Islands near the Subtropical Frontal Zone (STFZ). Most *B. japonica* were caught within the mixed layer in water temperatures of 17.5-19.8 °C; their distribution was limited to the south by the 21 °C isotherm. Satellite data depicting the location of the STFZ, in conjunction with catch data, indicate that larval and juvenile *B. japonica* were typically distributed to the north of the Subtropical Front. Ages and growth rates of 32 larvae and juveniles were determined through analysis of otolith microstructures: Estimated ages were 1-2 months, and estimated growth rate was 0.353 millimeter (mm) d^{-1} for 11-24 mm standard length fish and hatching dates based on back-calculated age estimates were January 2-30, 1991. An examination of the feeding habits of pomfrets caught by driftnet near the STFZ revealed that most of the stomachs were empty; hyperiid amphipods, along with other unidentified crustaceans, were predominant in the stomachs that contained prey.

Silberberg, K. R., and P. B. Adams. 1993. A comparison of the recreational and commercial fisheries for lingcod (*Ophiodon elongatus*) off the Pacific Coast of the United States, and a description of the recreational lingcod fishery. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-193, 29 p.

Somerton, D. A., D. R. Kobayashi, and K. C. Landgraf. 1993. Stock assessment of nehu, *Encrasicholina purpurea*, using the egg production method. Bull. of Mar. Sci. 53(2):768-777.

Nehu, *Encrasicholina purpurea*, are short-lived tropical anchovies used as baitfish for the Hawaiian pole-and-line tuna fishery. The spawning biomass of nehu within Pearl Harbor, Hawaii, was estimated weekly using the Daily Egg Production Method (DEPM). Over the 2-year study period, spawning biomass varied between 0.5 and 5.0 metric tons in response to the intensive fishery and a seasonal cyclicity in reproductive effort.

Wetherall, J. A., G. H. Balazs, R. A. Tokunaga, and M. Y. Y. Yong. 1993. Bycatch of marine turtles in North Pacific high-seas driftnet fisheries and impacts on the stocks. *In* Ito, J., et al. (eds.), INPFC symposium on biology, distribution, and stock assessment of species caught in the high seas driftnet fisheries in the North Pacific Ocean, Bulletin Number 53 (III), p. 519-538. Int. North Pac. Fish. Comm., Vancouver, Canada.

Four species of marine turtles, all listed as threatened or endangered by the International Union for the Conservation of Nature, have been documented in the bycatch of North Pacific high-seas driftnet fisheries. Bycatch rate data collected by observers, combined with driftnet fleet effort data, indicate a total marine turtle bycatch of about 6,100 turtles in 1990. The overall minimum marine turtle mortality due to driftnet entanglement in 1990 was about 1,700 turtles. Most of the mortalities were of loggerheads taken in the large-mesh driftnet fisheries of Japan and Taiwan. A reliable assessment of driftnet fishery impacts is hampered by lack of essential data on marine turtle population status and dynamics.

Wetherall, J. A., and M. Y. Y. Yong. 1993. A comparison of driftnet fishery bycatch estimation methods based on empirical bootstrap distributions. *In* Ito, J., et al. (ed.), INPFC symposium on biology, distribution, and stock assessment of species caught in the high seas driftnet fisheries in the North Pacific Ocean, Bulletin Number 53 (III), p. 359-365. Int. North Pac. Fish. Comm., Vancouver, Canada.

Two methods were compared for estimating the total bycatch of albacore, *Thunnus alalunga*, skipjack tuna, *Katsuwonus pelamis*, and blue shark, *Prionace glauca*, in the 1990 Japanese driftnet fishery for neon flying squid, *Ommastrephes bartrami*: (1) a standard method that expands the arithmetic mean of sample bycatch rates, and (2) the Pennington method, which expands the delta-lognormal estimator of the mean bycatch rate. Bootstrap distributions of the two estimators consistently showed that the Pennington method estimated higher total bycatch and wider approximate confidence intervals for total bycatch. The results agree with other findings published recently, indicating that the Pennington estimator is not robust with respect to the key assumption of lognormality in the positive bycatch rates.

Approved by Science and Research Director, SWR

Ballance, L. T. Flight energetics of free-ranging Red-footed Boobies, *Sula sula*. For consideration for publication in Physiological Zoology.

Bigelow, K. A., J. T. Jones, and G. T. DiNardo. Growth of the Pacific pomfret: A comparison otolith and length-frequency (MULTIFAN) analysis. For consideration

for publication in Canadian Journal of Fisheries and Aquatic Sciences.

Dewar, H., R. W. Brill, and K. R. Olsen. Rapid communication: The secondary circulation of the vascular heat exchangers in skipjack tuna, *Katsuwonus pelamis*. For consideration for publication in Journal of Experimental Biology.

Keen, J. E., S. Aota, and R. W. Brill. Cholinergic and adrenergic regulation of resting heart rate and ventral aortic pressure in two species of tropical tunas, *Katsuwonus pelamis*, and *Thunnus albacares*. For consideration for publication in Journal of Experimental Biology.

Kobayashi, D. R., and K. E. Kawamoto. Evaluation of shark, dolphin, and monk seal interactions with Northwestern Hawaiian Island bottomfishing activity: A comparison of two time periods and estimate of economic impacts. For consideration for publication in Fisheries Research.

Lyons, M. L. G., P. E. Smith, and H. G. Moser. Comparison of cross shelf trends in acoustic doppler current profiler amplitude and zooplankton displacement volumes in Southern California. For consideration for publication in California Cooperative Fisheries Investigation Reports.

Moffitt, R. B., and F. A. Parrish. Habitat use and life history of juvenile Hawaiian pink snapper, *Pristipomoides filamentosus*. For consideration for publication in Marine Ecology Progress Series.

Polovina, J. J., W. R. Haight, R. B. Moffitt, and F. A. Parrish. The role of benthic habitat, oceanography, and fishing on the population dynamics of the spiny lobster (*Panulirus marginatus)* in the Hawaiian Archipelago. For consideration for publication in Crustaceana.

Townsend, R. E., and S. G. Pooley. Toward corporate models of fisheries governance. For consideration for publication in Human Systems Management.

Van Geen, A., and D. M. Husby. Cadmium in the California Current System: Tracer of past and present upwelling. For consideration for publication in Journal of Geophysical Research (Oceans).

Administrative Reports

Administrative Reports are strictly for internal use only and are not to be cited or treated as publications.

Honolulu, Hawaii

Hamilton, M. 1994. NWHI bottomfish fishery 1993 vessel activities, costs and economic returns. SWFSC Admin. Rep., Honolulu, H-94-01C, 36 p.

Landgraf, K. C., and D. R. Kobayashi. 1993. Time series of environmental variables, abundance, and catch data (1986-88) for nehu (*Encrasicholina purpurea*) at Pearl Harbor, Oahu, Hawaii. SWFSC Admin. Rep., Honolulu, H-93-19, 34 p.

La Jolla, California

Childers, J., and L. Halko. 1994. Length frequency database description: California Department of Fish and Game gill net market samples. SWFSC Admin. Rep., La Jolla, LJ-94-01, 52 p.

Translations

Murakami, K., Y. Watanabe, and J. Nakata. 1981. Growth, distribution and migration of flying squid (*Ommastrephes bartramii*) in the North Pacific. Hokkaido University. (Engl. transl. by W. G. Van Campen, 1994, 26 p., Transl. No. 148; available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396.)

Kitana, K., and K. Iguchi. 1974. On some features of the seamount fishing grounds of the central North Pacific Ocean as seen from trawling surveys. Hokkaido University. (Engl. transl. by W. G. Van Campen, 1993, 6 p., Transl. No. 150; available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396.)

UNITED STATES
DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
SOUTHWEST FISHERIES SCIENCE CENTER
8604 LA JOLLA SHORES DRIVE
P.O. BOX 271
LA JOLLA, CALIFORNIA 92038-0271

OFFICIAL BUSINESS
PENALITY FOR PRIVATE USE, $300

THIRD CLASS